SUPPLEMENT TO "CURRENT SCIENCE".

Reviews.

THE THEORY OF UNEMPLOYMENT. By A. C. Pigou, M.A. (Macmillan & Co. 1933. Pp. 319.) Price 15*s*. net.

In a brief study of the problem of unemployment published in the Home University Library Series about two decades ago, Professor Pigou had examined the broad economic factors which govern the causation of unemployment, and discussed its remedies and palliatives. His main conclusions were firstly, that even in a stationary industrial state unemployment would be a necessary result, if the wage-rate, instead of being left to be adjusted by the free play of economic forces, is forced up either by collective bargaining through Trade Unions, or by humanitarian or legal compulsion in favour of a minimum wage ; and secondly, that in the non-stationary conditions of real life, the rigidity of the wage-rate, the impediments to the nobility of labour, and the fluctuations in the demand for labour operate as additional causes for the production of unemployment.

The present volume deals with the same problem in a much more thorough and scientific manner, with a definite aim at such completeness as can be attained in the present stage of knowledge, and with all the precision and careful analysis which students of economic science have learnt to associate with the name of Professor Pigou. The various types of causes and economic situations relevant to the amount of unemployment are here systematically classified and listed, and in the investigation of each the analysis is sought to be pressed to the farthest feasible point. This new book must therefore be welcomed, not only for its great disciplinary value to the advanced student, but as a classic achievement which extends considerably the limits of economic analysis, and furnishes a basis and a scaffolding for future work.

It is also a matter for congratulation that Prof. Pigou has definitely decided in this new book to adopt mathematical analysis as the avowed instrument of economic investigation ; indeed considering the nature of the subject-matter and the intricacy of the analysis, any decision to the contrary would have been inconceivable. Prof. Marshall, the predecessor of Prof. Pigou in the Cambridge Chair, in his *Principles of Economics*—and we may add, Prof. Pigou himself in his *Economics of Welfare*—created the fashion of dressing up private mathematical reasoning into elaborate non-mathematical language for the edification of the public. The clear advantage in discarding this pretence ("Cotton-wool", as the author aptly terms it in the Introduction) is that the certitude and clarity in the mind of the writer is communicated directly and without hindrance to the reader. One recalls in this connection the controversies about the applicability of mathematical reasoning to economics, in the early days when economic concepts were in the nebulous formative stage—controversies all the more violent as both the protagonists and the opponents often suffered from fundamental misconceptions. It was doubtless the desire to avoid such misconceptions that must have led Marshall to give the advice "to burn all mathematics" in his private correspondence, and must have been partially responsible for the suppression of the mathematical element in his work. However, this phase of economic science belongs definitely to the past. To-day the term 'mathematical economics' is a misnomer ; there is, on the other hand, only one economic science, and mathematical analysis is the essential and irreplacable instrument of its reasoning and method. What in fact would remain of modern economics if demanded of the ideas of its great creators, Jevons, Cournot, Walras, Pareto—ideas, economic indeed in their content and significance, but mathematical in their form ? The fact that most Indian Universities (who are generally content to stay, at a modest estimate, about fifty years behind time) have declared in favour of 'non-mathematical' economics, does not render it any the less true that economic science loosened from the ballast of mathematical reasoning, becomes degraded into vague statements, referring to the qualitative interdependence of various loosely defined economic entities, and leading nowhere in particular.

The book is divided into five parts of

which the last deals with the main theme, while the others prepare the ground by studying the precise relation of the quantity of unemployment to various other economic factors. Part I is devoted to preliminary considerations, to the precise definition of unemployment and to the relation of the volume of unemployment to the flow of wage-goods. In Part II a fundamental formula is obtained for E_d, the elasticity of real demand for labour in a single centre under competitive conditions, in terms of (1) the elasticity of demand in terms of wage-goods, for the new output at works of the finished products, (2) the elasticity of supply of the raw material, (3) the elasticity of the productivity function of labour, (4) the ratio of the demand price of the finished product to the price of the contained raw material, and (5) the ratio of the money-wage to the money value of the net output per head of the labour employed. The case of several centres of production, and the differences made by monopolistic conditions and by the rate of interest due to the deferred character of the return to labour are then examined. The elasticity E_r of the real total demand for labour (that is, in the wage-good and non-wage-good industries together) is next expressed in terms of the elasticity of real demand for labour in the wage-good industries. The last chapter studies the money elasticity E_m of the total real demand for labour, refutes the popular fallacy that $E_m=0$, and derives a formula for expressing E_m in terms of E_r, on the hypothesis that the total money income is a function of the total real income.

Part III defines 'improvements' in the supply of raw material, in the demand of the new output of the finished commodity, and in the productivity of labour, and studies the effect of such improvements on the real demand for labour, and the rôle of various factors, such as seasonal and other variations in people's desire, State stimulation, interrelations of utility between different commodities, etc., in producing fluctuations in the demand for labour. Several other aspects of the question, including the effect of change in the rate of interest, are also examined.

So far the argument has been from the 'real' end, that is, in terms of wage-good units, implying the use of an index for the cost of living or the general price level. Part IV studies the influence of monetary factors by means of a hypothetical standard monetary system, in which the aggregate money income varies only with the variation in the several factors of production, the price level varies inversely with the productive efficiency other things being the same, and the total stock of active money increases with the total money income so that the income-velocity remains the same. We have also an explanation how forced levies and anti-levies of wage-goods result, if the bank rate of interest differs from the proper rate—which is the rate which maintains the standard monetary system.

The concluding part investigates the effect on the aggregate volume of unemployment of fluctuations of real demand for labour in different centres of industry, of wage-policy and of other factors. According to the author's view it is the state of real demand for labour which is the essential determinant of the percentage of unemployment, and the real wage-rate stipulated for by work-people in normal times is always adjusted to the average state of real demand for labour. Hence he is not inclined to attribute much significance on the high correlation between real wage-rate and unemployment, obtained in recent statistical studies. Such significance can only result, according to the author, if changes in the real wage-rate are independent of changes in the real demand for labour. In fact, however, a shift in the demand for labour may produce shifts either in the same sense or in the opposite sense in the real wage-rate.

In spite of the handicap of the lack of statistical data for testing or justifying the results obtained, the increased insight obtained from the book into the economic mechanism of unemployment, and the number of definite results are considerable. A combined organisation of all governments and trade organisations to gather extensive and reliable economic statistics, somewhat on the lines of recent work in America, would result in a few years' time in untold progress to economic science.

The large number of mathematical formulæ in the book, seems to have occasioned many printer's errors and author's corrections; over and above those listed in the Errata, there are misprints on pages 58 and 136. The student may probably feel that some places in the book are not sufficiently explanatory. The theory of

interest dealt with in the footnote on p. 179 may with advantage be inserted into the argument at the bottom of p. 83. The treatment of the standard monetary system and the money factor could in places easily bear further explanation, without much danger of interrupting the main argument.

R. VAIDYANATHASWAMY.

ANALYTICAL GEOMETRY. By Vincent C. Poor, PH.D. (Chapman & Hall Ltd., London. 1934. Pp. 244.) Price 13*s*. 6*d*. net.

This new text-book, in splendid get-up, is very ably written for the first year course in colleges and presents some unusual features. It is conceived on broad lines, and without going into detailed developments in any topic is able to keep the emphasis throughout on the general apparatus of ideas and procedure, characteristic of the subject. The ground covered is wide. In addition to conics (general equations of the 2nd degree, standard forms of the parabola, ellipse and hyperbola asymptotes, diameters, pole and polar) and transformation of co-ordinates, we have an elementary chapter on the tracing of higher plane curves and the fitting of polynomial curves to statistical data; and the final quarter of the book is devoted to Solid Geometry and proceeds as far as is necessary for a general notion of curves and surfaces including the different types of ruled and non-ruled quadrics. One appreciates the Introduction of elementary plane and solid geometry at the same stage to the pupil, without making the usual artificial distinction between them. It is quite likely that certain portions, for example the ruled and non-ruled quadrics, may prove too difficult for the first year of the University (which would correspond to our Senior Intermediate), but the general tone is elementary and one does get the impression that the major part of the book, on the lines on which it is written, would be a feasible course for the first year. This of course does not apply to the Indian Universities which have sought safety by completely mechanising their education and their curricula and afford little scope to the original-minded teacher for initiative or experimentation in teaching.

It does not strike one in reading the book that the vector concept is used to any special extent or in unusual or novel situations. It is therefore surprising to find that the author claims in the introduction the use of the vector idea as the justification for this new book. Apart from the fact that the book offers several other novel features for consideration, this particular claim is misleading and tends to raise false expectations. By ' vector geometry ' one would understand a method in which, even though the proofs may be analytic, the outlook and the theorems are all synthetic, that is, are stated in terms of the geometrical elements (point, line, vector, etc.) *as such* without breaking them up into co-ordinates. It is problematic whether such a synthetic viewpoint can be introduced in a first course in analytic geometry with any success.

In certain cases, the author's interference with convention has not turned out happily. What for instances is the advantage in changing the classical nomenclature on ' one-sheeted ' and ' two-sheeted ' hyperboloids into ' un-parted ' and ' bi-parted ' ? What again is the justification for writing the general equation of the second degree without binomial co-efficients ? The writer who would do so has definitely no feeling for the theory of forms, which either overtly or covertly lies behind the geometry of plane algebraic curves. Again on p. 192, a cylinder is defined to be ' a surface generated by a line moving parallel to itself and tangent to a fixed curve'. The meaning intended for ' tangent ' here is not merely unconventional but unscientific. Lastly, the author while expatiating upon the fact that a line through the intersection of two given lines L, L′ is of the form L+kL′ has not thought it necessary to mention the symmetrical determinantal condition for the concurrency of three lines ! The only explanation of the strange fact that I can think of is that the intellectual bias of the author is directed away from the intuitions and values which derive from the theory of forms.

Another curious point is that while the author has throughout stressed the idea of ' locus ', he has omitted to mention the fact that the circle or conic $f(x, y)=0$ has two sides, the expression $f(x, y)$ taking different signs of these sides. This fundamental topological idea is not only important in itself (*e.g.*, in the question whether a given point is within or without a given circle or ellipse) but actually helps the learner to get a better grip on the difficult idea of ' locus '.

Lastly, there are two suggestions which I would like to make both to the present author and to writers of Introductory text-

books on Analytical Geometry. These, if followed, would in my opinion help the learner considerably and remove a certain fogginess from the subject. These are :—

1. To distinguish sharply the two meanings with which the word 'angle' occurs in analytical geometry, and to relate the two meanings to the concept of directed line. Namely, there are certain situations (*e.g.*, the slope angle of a line, the angle between two lines) in which the measure of the angle is relevant only mod π and certain other situations in which it is relevant mod 2π (*e.g.*, vectorial angle in polar co-ordinates, the angle α in $x \cos \alpha + y \sin \alpha = p$, p being positive).

(2) Whenever a square root occurs in an elementary formula, to explain why it occurs and why it would not but occur.

R. VAIDYANATHASWAMY.

SOLID MENSURATION. By Willis F. Kern. and James R. Bland. (Chapman & Hall, London. 1934. Pp. 73.) Price 7*s*. 6*d*. net.

This is a finely printed handy book on Solid Mensuration containing a list of fundamental formulæ and proofs of the more difficult theorems. The numerous illustrations and diagrams and the historical information about the various solids are attractive features. The real value of the book lies, however, in its large and unique collection of examples which are all of a practical nature and of a kind to interest the pupil. The authors intend this book for regular use in the secondary school and for the use of the backward student in the College.

It is notorious that the standard in Solid Geometry in the secondary education of this country is very low. The higher mental functions of the genus 'man' depend entirely on the two forms of his thought, the visual and the auditory. The latter is of course very important and is related closely to man in his social relations; as the factor which is responsible for the preservation and transmission of conscious race memory it is fully represented in our education. But it is the former which is at the root of all higher imagination and creative thought, and it receives considerably less than its due share of attention in our education. Discipline in Solid Geometry and Mensuration fairly early in the secondary stage is the only feasible method in general education for stimulating the potentialities of visual thought.

R. VAIDYANATHASWAMY.

CARRES MAGIQUES AU DEGREE N. By E. Cazalas. (Hermann & Co., Paris. Pp. 191.) 40 francs.

This book by Cazalas expounds the Tarry-method of constructing magic squares. In a note by Gaston Tarry presented by Henri Poincare to the Paris Academy of Sciences, he announced that it was always possible to construct a magic square of side p^n, which is magic up to degree n provided the least prime factor of p be large enough; *i.e.*, it is possible to fill up the square with the numbers from 0 to p^{2n-1} in such a way that the sum of rth powers of numbers in any column or row is the same for all integral $r \leqslant n$. It is really remarkable that the method of construction depended only upon the solution of certain linear congruences. Unfortunately, Tarry did not publish his method although he gave numerous examples of such squares. In the present treatise the author has given us a method of solving the general Tarry-problem by making use of the numeral series of Tarry. The book merits not only the attention of those engaged in mathematical recreations, but also of mathematicians as well.

The book is divided into seven chapters. It also contains a historical review of the subject of magic squares and at the end we find a complete bibliography. The first chapter defines the numeral series of Tarry and various notions such as panmagic, diagonal magic, etc. It also gives the method of construction of magic squares when the number of houses in each column or row is a prime number. In the second chapter we come across the construction of magic squares of side p^2 where p is a prime number which is also bimagic, *i.e.*, the sum of the squares of the numbers of elements in each row or column is the same. The third chapter deals with squares which are trimagic. In both these chapters, the way of construction of magic squares with other magic properties is also expounded. Numerous examples are also given. The fourth chapter deals with squares of side p^n which are magic of various degrees. Magic squares with some special magic properties are dealt with in Chapter V.

Chapter VI deals with squares of side m, where m is composite. In Chapter VII the mixed Tarry series are used for the construction of magic squares. Generalisation to magic hypercubes in various dimensions are also given. After the bibliography

a square of 64 sides which is magic upto degree 3 is given.

One commendable feature about the book is that it does not presuppose any mathematical knowledge on the part of the reader. The lovers of magic squares owe a deep debt of gratitude to the author for his beautiful treatise on the subject.

K. V. I.

ETUDE DES FONCTIONES SONSHARMONIQUES AN VOISINAGE D'UN POINT. By Marcel Brelot. (Hermann & Co., Paris. Pp. 55.) 14 francs.

Sub-harmonic functions can be looked upon as a generalisation of potential functions or as an extension of the notion of convexity to functions of two variables. Not only are they interesting in themselves but they are also useful in some problems in potential theory such as the existence of a solution of certain allied differential equations, and in the discussion of the behaviour of a potential function in the neighbourhood of its boundary. The development of the subject owes much to the work of F. Riesz and Montel. This monograph, third in the series of Memoirs published in honour of the mathematician Jacques Herbrand who unfortunately died at the early age of 23 after contributing very interesting papers on mathematical philosophy and algebraic numbers, is written in a very lucid and excellent manner.

The work is divided into three chapters. The first chapter deals with the general properties of sub-harmonic functions and their intimate connection with harmonic functions. The second chapter deals with properties of a function sub-harmonic in the neighbourhood of a point but not sub-harmonic at that point itself. After defining the maximum modulus, some properties analogous to the properties of analytic functions are also enunciated and proved. The theorem about the continuation of the sub-harmonic function to the point in case it is bounded, is very interesting and it is a generalisation of Riemann's theorem in analytic functions. At the end of the chapter, three examples of sub-harmonic functions are given behaving at the point in very singular ways. Some results are also generalised to the case of functions which are sub-harmonic in the neighbourhood of a closed set of points of measure zero. The third chapter is devoted to applications. Some results in connection with Wienner's generalisation of Dirichlet's problem and the existence and properties of the solutions of certain differential equations allied to Laplace's equation are discussed. For simplicity, the author has confined himself to two dimensions for, the generalisation of the results to any number of dimensions is direct and very simple.

K. V. I.

ELEMENTARY PRACTICAL MATHEMATICS. By J. W. Chaithness, B.A., B.Sc. (Chambers Ltd., Edinburgh. Pp. 318.) Price 3*s*.

Like general science, Practical Mathematics is looming large now-a-days in the curricula of studies for Secondary Schools. The student desirous of going to a technical school, after he finishes his school certificate, need not know all the aspects of Mathematics, which have a purely theoretical value. What the student of technical studies requires to know is, that aspect of mathematics, which will be of direct interest to him in his technical studies, be it Engineering, Building trades, or a higher branch of specialised science. Books dealing with this aspect of Mathematics are generally welcome.

The author is the Principal of a Municipal Technical School in England, and is thus specially qualified to write books on Practical Mathematics. The student of the Technical School should know enough Mathematics to enable him to get his workshop or laboratory results, with ease and accuracy. He need not know for instance the proof of a certain principle but he needs to know its application. What is attempted in the present work is the exposition of these principles and methods which are of general application to all technological studies. This book is intended to cover the course prescribed for Central Schools and Preparatory Technical Schools of England. It is expected that the course dealt with in this book will prove to be of great use and will serve as a foundation on which the more advanced Mathematics of the Engineer or the Physicist may be built. In addition to the useful portions in Arithmetic, Algebra and Geometry, a chapter on graphs and applications of calculus to approximations, areas and volumes, is given, which will be highly useful to the student for whom the book is specially meant.

The vocational and technical schools now developing in India will find this book immensely useful.

The printing and get-up of the book are excellent.

B. V. SASTRY.

THE LABORATORY WORKSHOP. By E. H. Duckworth and R. Harries. (Published by G. Bell & Sons, Ltd., pp. xi+246.) Price 10*s*.

It is now generally recognised that a certain amount of workshop experience or at least a little deftness in the use of the more common tools is a necessary adjustment to one's education. The post-graduate student, the science teacher, and all those who take up science as a profession will in their experience meet with diverse problems wherein a little familiarity with tools will prove to be of immense value. This means not only a saving of time but also a certain amount of stimulus to new ideas, and designs, of apparatus with which they may be concerned. This little book is written to help one acquire this knowledge.

The book opens with a description of practically all the tools that one is likely to handle in the workshop. There are some valuable hints as regards the choice of tools and other materials to equip a small laboratory workshop. The chapter on the properties of various materials that are ordinarily used in the construction of apparatus is very useful. The common operations, such as, cutting, filing, chiseling, drilling and bending, are fairly well explained and should certainly be valuable to the beginner. The operations involved to cut screw threads with the help of taps and dies are really very simple. But it is a common experience to see the beginner take up to this with a certain amount of nervousness usually ending in the most disastrous results, as evidenced by the number of broken taps and dies that fill what was once a complete set of screw plates. In view of this the authors have written a fairly elaborate chapter on screw cutting which will make one realize how simple it is to do the job if one only remembers the important hints detailed there. Another chapter is devoted to the very useful art of soldering. One often notices in the workshop, young men who can hardly resist the temptation of wistfully watching with admiration and envy the expert, who handles it with such ease and confidence. The hints and tips on soldering will go a long way at least, to give confidence, if not make an expert of a beginner. The final chapter giving examples of construction of various scientific apparatus is helpful in suggesting further work on similar lines.

The authors' intention of stimulating the dormant talents of "invention" and "resourcefulness" in young men, by omitting to mention anything that has to do with lathes is rather questionable, or at least true only to a very limited extent. Really there is no end to the variety of ingenious uses a lathe can be put to, and one is rather inclined to think that the use of a lathe will prompt young men to construct exceedingly ingenious apparatus, sometimes of far-reaching consequences, which would not otherwise be possible. The practically-minded man is surely deprived of what is perhaps the most interesting part of his experience. The inclusion of a couple of chapters on lathes and simple turning would certainly have been most salutary to the interests of ingenious young men, and made the field of usefulness of this book more extensive. But still within the limit set upon by the authors the book does serve a useful purpose, in introducing the beginner to the workshop, and providing useful hints to those constantly in need of the use of one, and in providing an excellent book of reference for general use.

C. C.

ALTERNATING CURRENTS. By L. T. Agger. (Macmillan & Co., Ltd., London. 1934.) Price 5*s*.

This book is divided into 15 chapters most of which are devoted to the fundamentals of alternating currents. The opening chapter considers the production of alternating voltage and current, their effective values and meaning of power in a circuit containing resistance only. The following 8 chapters deal with the meaning and value of inductance and capacitance and the behaviour of series and parallel circuits containing combinations of resistance, inductance and capacitance. Chapters 10 and 11 deal respectively with the properties of polyphase currents and power in polyphase circuits. Although the ground covered in these 11 chapters is the same as in the opening chapters of most text-books on alternating current engineering, the subject is treated with clearness and simplicity which cannot easily be surpassed. Chapters 12-14 deal with the elements of transformer, alternator and induction motor and the last chapter with measuring instruments.

The author has made use of a large number of diagrams, curves and examples in the text to give the reader an unmistakable idea of the points dealt with and exercises are given at the end of each chapter. This is the simplest book that the writer has seen and it is difficult to imagine that anybody going through it can fail to get a correct conception of the most important fundamentals of alternating currents.

J. J. R.

THE ELECTRONIC STRUCTURE AND PROPERTIES OF MATTER. By C. H. Douglas Clerk. (Chapman & Hall, Ltd., London.) Pp. xxv + 373.) Price 21*s*. net.

With the present rapid rate at which atomic and molecular theories are progressing, it is increasingly difficult to keep in touch with developments not in one's immediate sphere. Consequently any attempt made at presenting in a lucid and cogent manner the ideas developed in the several branches of the same science and particularly their inter-relations with each other, should be welcome not only as a food for thought, but also as a stimulant for further progress in the particular branch one is specialising in. Such a task has been undertaken by Mr. Clark with a zeal that has resulted for the present in three volumes forming the commencement of a series in "A Comprehensive Treatise on Atomic and Molecular Structure". The book under review is the first in the series, and is divided into two parts the first of which deals with the atomic and electronic quantum numbers, the inward nature of the periodicity of elements, the modifications to the original Bohr's concept of quantum numbers, the theory of inner building in the transition and rare earth elements and its bearing on the diverse valency possibilities, and ends with a very general review of the older electronic and the newer quantum and wave mechanical interpretations of different types of atomic linkages. Full details are not generally gone into but either postponed to later volumes or referred to original papers.

The second part deals in greater detail, though still in a rather summarising manner with the various physical properties of matter and their relation to the electronic structure. The subjects treated are in the order, melting and boiling points, atomic and molecular volumes, atomic and ionic radii, electrical conductivities of elements and crystals and related photoelectric effects, the conductivity of melted compounds and its bearing on several factors such as valency and size of the ions, the phenomenon of super conductivity and theories of super conducting state, magnetic susceptibility, additivity relationships, dia-para- and ferro- magnetism, atomic magnetic moments, cohesive force, surface tension, coefficient of expansion, and lastly entropy and its significance.

It is not possible to indicate any particular aspects of the subject that have been neglected, as in the author's scheme the three projected volumes form one unit, and frequent cross references are given to the second and third volumes which are "in preparation". It can, however, be said that the author has succeeded in giving a faithful running account of the trend of modern ideas regarding the properties of matter, and when any further details are wanted they can be either found in the latter volumes or in the references to the original and other "summarising" papers listed at the end of each chapter.

The practice of collecting together at the end of each chapter all the references is not always commendable, but seems to be well suited for the kind of book under review, where a group of papers on the same topic are given together with the necessary full titles of the papers. However, the peculiar list of abbreviations adopted by the author for the names of the journals seems quite uncalled for; unfortunately there is no standard practice adopted in this respect in the scientific literature, but still to some degree the abbreviations used conform to a certain type, and the aim should be to try and standardise the abbreviations in use rather than invent unnecessarily new ones such as 'C' for Transactions of the Royal Society of Canada, 'C. R.' for Chemical Reviews, 'F' for Transactions of the Faraday Society, and 'P. M.' for Philosophical Magazine, and others such as 'C. L.' or 'R. M. P.' The author himself has used in p. 86, for reference No. 27, the abbreviation 'T. F. S.' which is not to be found in the list given in p. xxiii, and which is obviously a mistake for 'F' the Transactions of the Faraday Society.

There are a few printing mistakes in the text such as those in p. 22, l. 1, p. 226, l. 19 or p. 236, l. 4, and others in the equations 9*b* in p. 331, and those given in the top of p. 335.

The publishers have done their task well and the printing and binding are up to their well-known standards.

M. A. G.

THE FUNDAMENTALS OF CHEMICAL THERMODYNAMICS. PART II. THERMODYNAMICAL FUNCTIONS AND THEIR APPLICATIONS. By J. A. V. Butler, D.Sc., Lecturer in Chemistry in the University of Edinborough. 271 pages. Price 8*s*. 6*d*.

This little book is the second part of the author's 'Fundamentals'. Although the more elementary calculation of maximum work and simpler applications of first and second laws of thermodynamics have been treated in Part I, the subject has been discussed in fuller detail and from more advanced point of view using thermodynamical functions in the classical manner so that the present volume is tolerably complete by itself.

The system of symbols used is that of Lewis and Randall the corresponding notations of Gibbs and German workers being also given to assist when referring to original papers. Unfortunately, the author has given the standard values for energy and entropy referred to 25° as against the German practice of calculating these to absolute zero.

The third law has been developed with due regard to the methods of Nernst and Lewis and mention is made of the American work on supercooled liquids and a brief discussion on the chemical constants of simpler gases.

The main feature of this book is the comprehensive discussion of the properties of solutions especially of electrolytes which has apparently salted out, the more important applications of thermodynamics to equilibria in organic reactions and reactions at high temperature. This partiality is obviously due to author's own contributions to the subject of solutions which he has treated in a lucid, thorough and up-to-date manner. This is very welcome especially in view of the long time having elapsed since the appearance of the well-known work of Lewis and Randall whose clear and pleasant presentation of the subject remains unsurpassed.

There is a unique chapter on the thermodynamics of surfaces. The activity concept is applied to adsorption from solutions. The last chapter gives a concise discussion on the Phase Rule and the geometric methods of Gibbs as applied to the stability of binary and ternary systems.

There are up-to-date references to papers including author's own and an index at the end. The paper, printing and get-up is good and price moderate. The students of physical chemistry will find this book a welcome help.

LA NOTION DE CORPUSCLES ET D'ATOMES. By Prof. Langevin. (Hermann & Co., Paris.)

With the ever-increasing isotopes, the neutron and the positron, to say nothing of the now old electron, proton and photon, our knowledge of the constitution of matter is extending both intensively and extensively at such a rapid pace that it is quite a job for anybody to keep in view, if not in touch, with modern progress in all its details. It is hence a signal service which Prof. Langevin has done in his address on 'La Notion de Corpuscles et d'atomes' published by Hermann et cie, Paris, as Report No. 132 in the well-known series "Actualites Scientifiques et industrielles" 1934 (price 12 fr.). Prof. Langevin has started at the very beginning so that even a Rip Van Winkle in science cannot complain of any links missing in the chain of progress. He begins with the Democritian doctrine of the divisibility of matter and the existence of ultimate particles and pays a tribute to chemists for having followed up the idea and placed it on a quantitative basis in their elucidation of molecular and atomic weights. Both these quantities are, however, only comparative values and it is due to the more exact sister science that an accurate knowledge of Avogadro's number was possible and thence an absolute value for those quantities. The next step in the progress came with the advent of the cathode tube in the last quarter of the last century and with it the idea of corpuscles.

A brief but coherent account is given of J. J. Thomson's experiments for establishing the electron as a definite physical entity, of Lorentz's theoretical conception of an electrified granular structure of matter for explaining certain optical phenomena on the electromagnetic theory and Wilson's cloud chamber methods of, as it were, visualising the electron. He explains how photographs taken by the cloud chamber methods were used to verify the photoelectric law on the equivalence of energy exchange between matter and radiation, a verification which led on to the conception

of a structure of radiation, a ground already prepared by Planck, Einstein and others in their discussions on the emission and absorption of radiation by matter, the spectral character of blackbody radiation and the inertia of energy. Mention is also made of Compton effect as experimentally confirming the corpuscular conception of both matter and radiation. Rutherford's experiments on radioactivity and the disintegration of matter leading on to the conception of the proton and the nuclear atom model are described with suitable photographs taken by the cloud chamber method. Finally, the experiments of Bothe and Becker and the discussions thereon of Chadwick and others leading to the discovery of the neutron and the positron are explained in an interesting manner. Thus in a brief but very illuminating review Prof. Langevin has brought out our modern corpuscular conception of the universe as consisting of electrons, protons, neutrons and positrons on the material side and photons on the energy side, the two sides, however, being mutually convertible.

Having thus summarised the present experimental knowledge on the structure of matter, Prof. Langevin proceeds to review the situation from the theoretical viewpoint. After a brief reference to the classical electromagnetic theory and its limitations when applied to the dynamic atom, the introduction of Planck's quantum conditions in the mechanics of the Rutherford-Bohr atom model, Prof. Sommerfeld's exhaustive and successful treatment of the hydrogen atom and its limitations when applied to atoms with several electrons, mention is just made of the development on the one hand of matrix mechanics by Heisenberg, Born and Jordon and on the other hand of wave mechanics by Louis de Broglie, Schrodinger and Dirac. Prof. Langevin gives a clear though very brief account of the train of thought that led on to the wave conception of matter, mentioning the experiments of Davisson and Germer and G. P. Thomson.

This brings him on to the greatest pitfall of all in modern science, *viz.*, the dual conception of the electron, corpuscular at times and undulatory at other times. The dual nature of the electron has been the two horns of a dilemma between which, not being able to choose one and exclude the other, scientists have been trying to strike a compromise. Bohr calls the two aspects complementary and has enunciated his principle of complementarity. Born, in trying to reconcile the two ideas, introduces a statistical character in the discussion which, however, destroys the objectivity of electrons, protons and photons. Heisenberg has, at this stage, introduced his Principle of Indeterminacy according to which it is not possible to know at once the position and momentum of an electron.

Prof. Langevin taking up the method of Born suggests a return to a statistical treatment. Knowing that the Boltzmann-Gibbs statistics has failed to agree with experiment, he suggests the applications of the Bose-Einstein and the Pauli-Fermi statistics with the Pauli's exclusion principle thrown in when dealing with charges. Mention is made of the successful application of this method by Bose, Debye, Jeans and others.

Prof. Langevin concludes with a moral disquisition on the effect of long habit on the anthropomorphic tendency of our minds in finding an object more easy to deal with than an idea. He makes a very interesting observation that the original conception of an object should have been as abstract as our present conception of an idea and just as in course of time we have familiarised ourselves with dealing with objects, we should begin now to deal in the abstract with conceptions and bequeath this habit as a convenient heredity to our posterity.

P. S. S.

THE HARDNESS OF METALS AND ITS MEASUREMENT. By Hugh O'Neill, D.Sc., M.Met. (Chapman & Hall. 1934. Pp. xiv + 292.)

This is a most valuable addition to the excellent series of books on metallography published by Chapman & Hall. Its scope is much wider than its precise title would appear to indicate. The theories underlining various concepts of hardness are very fully studied, physical, chemical and mathematical principles being exhaustively explained. The Static Ball Test is fully studied with particular reference to Brinell's test. The author devotes three chapters to consideration of hardness in relation to internal structures of metals. Of these chapters those on the crystalline nature of metals and alloying and heat-treatment are worthy of special commendation. The chapter on practical aspects of testing hardness is one that should be read by all engineers using hardness testing machines, especially with reference to the method of

preparation of a sample. The author's style is such as to make the book interesting and always readable even in the more mathematical portions. It is profusely illustrated and contains many beautifully reproduced photographs. A copious bibliography containing over 400 references adds to the value of this book.

CHARLES FORRESTER.

A TEXT-BOOK OF GENERAL BOTANY FOR COLLEGES AND UNIVERSITIES. By Richard M. Holman and Wilfred W. Robbins. Third Edition. (John Wiley & Sons. Inc. New York. 1934.) Price 25*s*.

As the authors have stated in the preface, the essential qualities of a good text-book have been recognised and kept up throughout the pages of this book. The arrangement of the subject-matter and its treatment deserve special appreciation. The first part of the book comprising about 300 pages not only introduces the reader to the realm of the biological science, but also takes him through the detailed mechanism and functions of the Flowering plants in particular. Seven chapters of this part have been devoted to the study of the chief parts of the plant body. The chapter on "The Stem" has been treated in a masterly way. The other parts of the plant body like Root, Leaf, Flower, Fruit and Seed have been treated with equal justification. The authors appear to be partial to anatomy rather than physiology. The chapter on the Relation of the Plant to its environment, really gives a true picture of the activities of the plant and the position of the plant in the organic world not as an isolated but as an interdependent unit of a large fabric.

The second part of the book is devoted to the study of the representative members of the other groups of plant kingdom, like Algæ, Fungi, Liverworts, Mosses, Ferns and Seed-plants. Full justice has been done to every one of these groups in their treatment and the beginner finds it very easy to follow the life-history of the plants, specially along the straight road with mile-stones and furlong-stones, as illustrated by the summary of the principal features in the life-history of wheat. The chapter on Evolution and Heredity gives the reader in a nutshell all the principal ideas and their associated views included in the above subjects, and has been presented in a graphic way. Even the latest ideas have been incorporated. The past history of the plants as evidenced by the Fossils has been dealt with briefly, giving a true picture of the vegetation of the land in those bygone days and the importance of the study of such vegetation in solving the problems of Evolution.

The book has been nicely got up and has been profusely illustrated. The drawings and sketches are scientifically accurate and their illustrative value has been enhanced by a large number of photo-micrographs that appear throughout the book. The fact that during these ten years, the book has gone through three editions, is a proof positive of its usefulness to the students and the teachers as well.

L. N. RAO.

GROUNDWORK OF BIOPHYSICS. By G. M. Wishart, B.SC., M.D. (George Bell & Sons, Ltd., London. 1931. Pp. vii+344.)

A study of the recent developments in Physiology or Biochemistry will show that progress in the fundamental conceptions of life processes can best be assured by a liberal application of the technique of the physicist. This is being increasingly recognised and the contributions of S. P. L. Sorensen, L. Michaelis, J. Loeb, W. M. Bayliss and T. B. Robertson only serve to emphasise this. To-day Physical Chemistry and Biophysics are included in the curricula of studies in Physiology and Biochemistry.

The book under review "is an attempt to aid the student by bringing within small compass those aspects of physical chemistry and physics which he will find most necessary in his physiological studies." One cannot help feeling that he is reading an elementary text-book of physical chemistry as he reads through the book. In the later half of the book an attempt is made to deal with selected sections of physiology such as *vision* and *hearing* which demand familiarity with such chapters in Physics as *optics* and *sound*. As a text-book for the University student, the publication will meet with his requirements. The treatment is elementary but clear and the book can be recommended to those who require to be introduced into the subject of Biophysics.

There are few printer's mistakes and the publishers deserve to be congratulated for the neat get-up.

SUPPLEMENT TO "CURRENT SCIENCE".

The British Association for the Advancement of Science, Aberdeen, 1934.

Presidential Address—The New World-Picture of Modern Physics.

By Sir James Jeans.

SIR JAMES JEANS delivered a highly thought-provoking address at the Aberdeen Meeting of the British Association for the Advancement of Science, taking as his theme "The New World-Picture of Modern Physics". He first commented on the happy auspices under which they had assembled, the Scottish meetings having been traditionally successful, but there was the early death of Sir William Hardy which he deplored and which he said had cast a shadow in all their minds. After paying an eloquent tribute to the excellent qualities of the departed, the lecturer proceeded to the subject of his address. In the fifty years' interval between the time when one theoretical physicist—Lord Rayleigh—had occupied the chair and the present occasion when again the presidentship had fallen to a theoretical physicist, the science of physics had changed and developed beyond recognition. The old explanations, based on an attempt to understand nature by means of familiar models, had failed to cover the new facts and the mathematical formulae which represented the facts well showed that the explanation was like a parable. The modern difficulties regarding the nature of the world were all due to the mistake of taking these parables to represent the actual truth. It is a natural tendency for man to prefer concrete facts to abstract principles, but since all measurement implies the comparison of one quantity with another of similar nature, we could become cognizant only of the relations which we ourselves discovered, but the essential nature of the quantity compared would be beyond comprehension. Thus all our knowledge about observables would be numerical or mathematical in content while whatever we thought we knew about unobservables would be pure assumption. That was the reason why the attempts of the nineteenth century physicists to explain the wave-nature of light by trying to picture the properties of the ether led to false conclusions. It was only the imagery that led people to expect a positive result in the Michelson-Morley experiment. The null-result showed the error of taking this imagery to be representative of external nature. Since the general theory of relativity showed that the space-time continuum could be twisted and warped as much as we please, even this continuum could not be itself part of Nature. Since all our knowledge comes through our senses it was but natural to postulate the existence of "matter" as a starting point for the effects which reached our senses, but this "matter" is as unobservable as the ether. For example, earthquake waves affect our houses by travelling along the surface of the ground but it is not right to assume that they originate in the surface. So also space and time or the space-time continuum might be the means through which our senses are affected but that would not prove that they were part of Nature.

Theoretical physics is no longer concerned to study the Newtonian Universe which it once believed to exist in its own right in space and time. It merely sets before itself the modest task of reducing to law and order the impressions that the universe makes on our senses. Its task resembles that of the map-maker who can represent different aspects of a region of the earth's surface by means of different projections, but who does not make the mistake of taking the map to be the earth. Newtonian physics was like the map of a small region in that it represented the motions of medium-sized objects correctly but failed to represent the infinitely great and the infinitely small. The new physics provided a map of the whole universe but some properties of the small map, such as representation in time and space and the old determinism, could no longer be found in the larger one. Just as the map-maker requires different kinds of maps to represent different aspects of the earth, theoretical physics provides two pictures—the particle picture and the wave picture. Bohr's theory of the hydrogen atom showed that the particle picture was inconsistent with Newtonian determinism—there was no way of predicting which particular atom would suddenly change in energy and radiate, as Einstein pointed out. But even this picture failed to represent the whole of experience. Then came the wave picture; this gives a wave in ordinary space only for a crowd of electrons moving as in an electric current, but the picture extends to more dimensions when other phenomena have to be represented. It has not been possible to combine the particle and the wave picture into one better representation as we can combine the different kinds of maps into a single globe. We cannot say whether it is impossible to arrive at such a unified picture or it is some ingrained habit of thought that is preventing us from realising it.

In spite of this lack of a unified representation of the Universe, the relation between the particle and the wave picture is definitely known. The more stormy the waves at any point in the wave picture the more likely we are to find a particle at that point in the particle picture. Yet if the particles existed as points and the waves depicted the chances of their existing at different points of space—as Maxwell's law does for the molecules of a gas—then the gas would emit a continuous spectrum instead of the line spectrum that is actually observed. Thus we had better put our statement in the form that the electron is not a point-particle, but that if we insist on picturing it as such, then the waves

indicate the relative proprieties of picturing it as existing at the different points of space. But propriety relative to what? The answer is—relative to our own knowledge. If we know nothing about an electron except that it exists, all places are equally likely for it, so that its waves are uniformly spread throughout the whole of space. By experiment after experiment we can restrict the extent of its waves, but we can never reduce them to a point or indeed below a certain minimum; the coarse-grainedness of our probes prevents that. There is always a finite region of waves left. And the waves which are left depict our knowledge precisely and exactly; we may say that they are waves of knowledge—or perhaps even better still waves of imperfections of knowledge—of the position of the electron.

But there is one surprising situation here; the waves are supposed not to be a picture of our knowledge of Nature, but of Nature itself. That would mean that Nature was in our minds and not external to the observer. The Nature we study is not the object of our perceptions but is made up of those perceptions themselves. We are forced to this conclusion because whenever the particle picture comes into conflict with the wave picture the wave-picture has been shown by observation to be the correct one. Such is the case in G. P. Thomson's experiments on the diffraction of electrons, or in the phenomena of the leakage of particles through a potential barrier. When we retain the particle picture and try to explain what peculiarity allows some out of a number of similar particles to get through the barrier, we will have to answer that it is a question of chance or Fate. For example, when we picture light as a swarm of photons, it is difficult to see why a certain number of them pass through a semitransparent obstacle, and which individual photons are thus singled out. Thus the behaviour of any individual photon—whether it will be reflected or transmitted—is indeterminate. But in the wave picture the question of the individual photon does not arise at all and hence the process is quite deterministic. Similarly, the principle of Pauli shows that an electric current should not be thought of as a swarm of identifiable electric particles. If two electrons collide and go off in two different directions we have no right to say that the latter electrons are the same as those that collided. The determinism which appears in the new physics is one of waves and so, in the last resort, of knowledge. Where we are not ourselves concerned we can say that event follows event; where we are concerned, only that knowledge follows knowledge. And even this knowledge is one only of probabilities and not of certainties. So it is impossible to decide whether our minds can change what is happening in reality or whether they only make it look different. The problem of free-will will hence remain a debatable question which cannot receive a definite answer. We cannot say that materialism is dead, but it has to be so refined that it may be doubted whether it may still be called materialism. The objective and material universe of the Victorian scientist is shown to consist of little more than constructs of our own minds. But the problem arises—why should all our minds construct the same nature? Sir James Jeans answers that it is probably because all our minds are parts of one whole, our individualism being merged in the stream of life when we cease to view ourselves in space and time.

Sir James then proceeded to show how the complaint that all our modern woes of unemployment and competition were due to the indiscriminate advance of science was not entirely well founded. He pointed out that the tragedy lay not in man's control over Nature but in the absence of moral control over himself. The remedy lies not in giving up science, but in extending its methods to other walks of life, by means of the science of psychology for instance. If economic depression and unemployment arise from rationalisation and scientific efficiency, science also provides new avenues of employment by creating new industries. It is certainly safer to solve the problem this way than to scrap science and sit patiently waiting for the catastrophe due to increase of population to come to us in the form of war, famine and disease. Nor is it right to decry pure science, for no investigator knows beforehand what discovery he is going to make and in what way it can be applied. If pure science is stifled, applied science will be nipped in the bud. So Sir James concludes by exhorting all thinking men and women to ponder and decide whether it is better to risk the fate of that over-ambitious scientist Icarus, rather than resign ourselves without an effort to the fate which has befallen the bees and ants.

Mathematical and Physical Sciences.

President: PROF. H. M. MACDONALD, O.B.E., LL.D., F.R.S.

"THEORIES OF LIGHT."

THE early theories of light started on the basis of a comparison with the way in which our other senses are affected. One view advocated by Empedocles took a hint from the sense of smell and imagined light to be some sort of emanation of particles from the luminous body; the other put forward by Aristotle compared light with sound and regarded it as undulations generated by the source. These views were revived in a more definite and quantitative form by Newton and Huyghens respectively. The ease with which the corpuscular theory accounted for rectilinear propagation and Newton's authority conspired to bring this theory into general acceptance until the beginning of the nineteenth century when Young showed how the wave-theory could be made to yield an explanation for the formation of shadows. The phenomena of interference, diffraction and particularly of polarisation were seized upon by Fresnel to establish the wave-theory on a secure foundation. Fresnel and Young were able to show that the light disturbance was propagated as transverse waves and Fresnel succeeded in explaining the optical properties of crystalline media and also the distribution of intensity and the polarisation of the reflected and refracted beams—a problem which had only found an *ad hoc* qualitative explanation in Newton's hypothesis of fits of easy reflection and easy transmission.

Now began a series of researches with the object of deducing the properties of the light-waves analytically from hypotheses as to the nature of the medium—the luminiferous æther—which transmitted the luminous disturbance. Cauchy

was the first to develop such a theory; later on Green discussed the problem from a more general viewpoint, only assuming that the mutual action of portions of the elastic medium were such that they possessed a work function. He showed that this function involved only two constants in the case of isotropic homogeneous bodies and that the velocity of propagation of normal waves must be infinite if the medium is stable. The difference between two isotropic homogeneous media is assumed to be a difference in their densities and formulæ are obtained agreeing with those of Fresnel—accurately in the case of waves polarised in the plane of incidence, and approximately in the case of waves polarised perpendicular to this plane. Green also assumed that the light vector was perpendicular to the plane of polarisation in agreement with Fresnel while Cauchy had assumed it to be in that plane. In these investigations Green used a general dynamical method due to Lagrange and extending it to the case of crystalline media he showed that in order to arrive at Fresnel's results one had to assume extraneous forces. Cauchy also came to the same conclusion that an elastic solid medium which is self-contained and free from external constraints cannot account for the observed facts. Various modifications of this theory were advanced, for example, by Lord Kelvin, but the final upshot of it all was to show that the elastic solid theory could not give Fresnel's results without further hypotheses and that agreement with Fresnel's results meant agreement with nature.

The next important advance was due to Faraday who showed that the plane of polarisation is rotated by a magnetic field. Faraday's views about light show his keen scientific acumen and are nearer to modern ideas than even Maxwell's theory. Faraday thought that the assumption of an æther was not essential for understanding light waves; they are according to him a "high species of vibration in the lines of force". (The modern view following upon the Relativity theory also discards an æther and contemplates vibrations of the electric and magnetic vectors without any thought for a medium.) Maxwell on the other hand attempted a dynamical theory based on the properties of an æther which behaved like an isotropic dielectric and which was assumed to be able to possess both potential and kinetic energy. He put the laws of Ampère and Faraday into a general mathematical form and obtained his famous equations. He also replaced the expression for the electrokinetic energy by one which gives the energy in terms of the magnetic force, by a process of integration by parts wherein the surface integral is neglected on the ground that at great distances it tends to zero; but in this he overlooked the fact that the law of variation of a magnetic field with distance is not the same when the field is varying as when it is steady. However, this expression is not used in deducing his equations which are thus unaffected. According to Faraday, however, it is not the æther that pervades all space but the forces of the atomic centres pervade all bodies, and it is the vibration of the lines of force and not that of the parts of the æther that is responsible for the propagation of electro-magnetic disturbance. The consequence of identifying light waves with electro-magnetic disturbances was to enable the velocity of light to be determined by finding the ratio of the electro-magnetic and electrostatic units of electric force.

Consistently with the above, the effect of material media can be represented by electric and magnetic currents throughout the space occupied by the material medium and these electric and magnetic currents may be supposed to be due to the motion of electric charges and magnetic particles, *i.e.*, the medium can be replaced by a distribution of electric and magnetic oscillators. When an electro-magnetic disturbance passes through such a medium the motion of the oscillators is disturbed and under certain conditions small oscillations will be set up about steady states of motion. The material of the medium may be considered to be transparent to such waves as set up only small oscillations, *i.e.*, those whose frequency is not near the natural frequencies of the oscillatoes. Fresnel's results for the intensity and polarisation of the reflected and refracted waves as well as his results for crystalline media can be obtained on this view without further hypothesis. Faraday's results for the rotation of the plane of polarisation also follow immediately. The view also shows that there are ranges of frequencies for which a medium is transparent and other ranges for which it is not transparent. The calculation in the case of these latter frequencies involves additional hypotheses.

The above theory is not a mechanical theory in the sense that a machine can be constructed whose motions resemble those of light. The form of the electrokinetic energy function leads us to doubt whether all time rates of change can be represented by the motion of points in space. We may have to contemplate time rates of change which do not involve changes of position in space although they satisfy the laws of dynamics. A possible hypothesis is that physical phenomena are due to the interaction of time rates of change which satisfy the laws of dynamics. The Lagrangian function will then be a homogeneous quadratic function of all the time rates of change. In practice some of these rates are observed while others are not; the experimentally deduced Lagrangian function will then be a modified one, not involving the unobserved changes.

Chemistry.

President: PROF. T. M. LOWRY, F.R.S.

"PHYSICAL METHODS IN CHEMISTRY."

IN his Presidential Address to the Chemistry section Prof. T. M. Lowry has taken for his subject "Physical Methods in Chemistry". Such is the significance of this topic at the present times that it has also formed the theme of a symposium held recently by the Deutsche Bunsen-Gesellschaft at Bonn (*Z. Electrochem.*, July 1934). Some of the many extremely interesting remarks made by the lecturer in his introduction are best quoted in almost his own words: "One of the most important features of scientific progress during the present century has been the renewal of the old intimate fellowship between chemistry and physics. Chemists who are no longer competent physicists and physicists who have little or no sympathy with chemical problems are a great loss to both sciences. The efficiency of my own Laboratory of physical chemistry at Cambridge and the pleasure that I derive from directing it depend largely on the fact

that the workers in the laboratory consist of chemists and physicists in approximately equal numbers, so that we are equally well equipped for work in the older physical chemistry and in the newer chemical physics. Indeed our chief need at the present time is for larger numbers of organic chemists to undertake researches in physical chemistry of organic compounds."

Brief reference is made to some of the principal contributions which physics has made to the progress of chemistry during the present century, such as the theory of atomic numbers, developments in the field of nuclear chemistry through the use of new projectiles for bombarding the nucleus, and the phenomena of X-ray and electron diffraction of molecules. Prof. Lowry then proceeds to give a graphic description of his 40 years of research work on the subject of optical rotation, and how from his first piece of work on the stereo chemistry of α-derivatives of camphor, "happy chances" led him on step by step from one discovery to another, from the discovery of *mutarotation* to its interpretation as an example of *dynamic isomerism* and its dependence on extra molecular circumstances. It was particularly observed that an amphoteric solvent must be provided to serve as a complete catalyst for this isomeric change in which a H atom migrates from one position to another (*prototropy*). This discovery was linked up in 1923 to an extended definition of acids and bases as proton donors and acceptors, an idea which was described more fully by Brönsted a few months later. This process of isomeric change can be regarded as an electrolysis of the organic molecule between the positive and negative poles provided by the acid and basic components of the amphoteric solvent.

Attention was then naturally directed to more quantitative studies of optical rotation and its change with the wavelength, *i.e.*, the dispersion. Drude's equation can express completely the rotatory dispersion for transparent media up to the extreme limits of accuracy now attainable. In general *normal* dispersion can be expressed with but one term of this equation, while *anomalous* dispersion requires the use of two terms of opposite sign. Dispersions can also be classified into *simple* and *complex*, according as they require one or more terms of Drude's equation. *Simple* rotatory dispersion, however, does not imply the existence of only one single partial rotation, but merely indicates that the partial rotations of the molecule can in practice be covered by one term of Drude's equation. Thus, in the remarkable case of tetra-acetyl-μ-arabinose H $(CHOAc)_4CHO$, the partial rotations associated with the three asymmetric carbon atoms cancel out, and the whole of the rotatory power is due to the partial rotation associated with the carbonyl group. This gives rise to a simple rotatory dispersion in the region of transparency. In the region of absorption it gives a symmetrical loop, with equal and opposite maxima $[\alpha] = \pm 1200°$, on either side of a zero rotation at 2909 Å. U. The dispersion in the absorption region is a complicated phenomenon, on account of the presence of damping factors which are discarded in Drude's simple equation for the transparent region. The attempts of Kuhn and Braun and of Hudson have been only partially successful in expressing accurately this dispersion. The sugar derivatives tetra-, and penta-acetyl-μ fructose provide ideal material for an experimental study of the form of the curves of rotatory dispersion in the region of absorption since the partial rotation associated with the carbonyl radical has been isolated automatically by a fortunate process of cancellation of the partial rotations of the asymmetric carbon atoms.

Regarding the origin of optical rotatory power, the real theory may be found by the mathematicians, but is concealed from the chemist, in the papers of Born, who recognised that *four* coupled electrons are required to produce optical rotatory power. Further advances appear to depend on reverting to this basis, in place of Drude's single spirally controlled vibrator, or Kuhn's two dissymmetrically coupled electrons. In the case of camphor we are dealing with an intra-molecular field of force which induces dissymmetry in the highly polarisable carbonyl group, rather than with asymmetric carbon atoms, which in the case of the sugar derivatives referred to, make no direct contribution of any importance to the rotatory power of the molecule.

The attempt made nearly ten years ago by de Mallemann, to predict the sign and magnitude of rotation of a molecule, assumed for purposes of computation single atoms as isotropic spheres. S. F. Boys has recently extended this postulate from single atoms to radicals, and has been able to deduce for four of the simplest alcohols and amines rotations which are of very similar magnitude to those observed experimentally. As this extension to radicals such as CH_2OH is certainly not valid, the agreement is perhaps more of the nature of coincidence. Besides, this formula cannot represent even qualitatively the anomalous rotatory dispersion of aldehydes and ketones in the region of absorption. No theory of optical rotatory power which is limited to the region of transparency can be regarded as satisfactory, and further progress must depend on an intensive study of rotatory dispersion in the region of absorption. When perhaps one has been able to determine by the methods of wave mechanics the conditions under which the electronic cloud of the carbonyl radical becomes optically active, and the factors which determine the magnitude of its partial rotation in order to provide a complete solution for this special case, the way will be paved for a general solution of the whole problem.

Geology.

President: PROF. W. T. GORDON, M.A., D.Sc.

"PLANT LIFE AND PHILOSOPHY OF GEOLOGY."

THE Presidential Address by Prof. W. T. Gordon to the Geology section of the recent meeting at Aberdeen, of the British Association for the Advancement of Science, deals with "Plant Life and the Philosophy of Geology". The paper is largely historical in character and begins with the palæontological ideas of the Greek and Roman philosophers. In these early times although many geological processes and phenomena were known, there was no science of Geology. Even in mediæval times the idea still prevailed that fossils were produced in the earth by "stone-forming essences"; although there were few like Leonardo da Vinci and Fracastoro who recognised the important fact, that fossils were true organic remains buried in the rocks of the earth's crust. The earlier people must have had ample opportu-

nities of unearthing fossil remains during the excavations for tanks, foundations, etc.; the paucity of references to such fossils in contemporary literature can only be attributed to an apathy and extraordinary lack of interest in them. Gradually, however, the organic nature of fossils was established as a principle of scientific philosophy and even so early as the sixteenth century they came to be studied in the proper spirit and method of enquiry; and during this period fossil plants came in for a lot of attention in the hands of such workers like Palissy, Steno, Robert Hooke, Martin Lister and John Woodward. Thus the stimulation for the collection of fossil plants increased and the literature dealing with them began to grow which involved not only the palæontological aspect but its application to larger geological problems.

Fossil Botany as a Science was initiated by Adolphe Brongniart when in 1828 he published the first part of his "Histori des Vegetaux fossiles", with the illuminating sub-title "Botanical and Geological Researches on the Plants sealed up in the different Rocks of the Earth". This important publication placed the study of fossil plants on a scientific basis and Brongniart well deserves the title of the Father of Fossil Botany. While these researches were based mainly on the study of incrustations of plants, a new method was devised by Henry Witham in 1833 for the investigation of their internal structure by the examination of thin sections. The advent of this new technique at once divided the study of fossil plants into two sections—one biological and the other stratigraphical. As a direct result of the development of the study of micro structure of plant fossils we see the recognition of such groups as Psilophytales, Pteridosperms and Caytoniales, groups which throw considerable light on the ancestry of the different phyla of the plant kingdom. Further, similar microscopic studies enabled Kidston and others to show the distinctive nature of the floras in geological times and their utility for stratigraphical correlation. Another phase of research in plant palæontology is the quantitative type which has been explored by David Davies with such striking results in the correlation of coal seams over wide areas, especially from the spore content of the coal. The advent of the new technique recently introduced in 1933 by Hickling and Marshall on the study of bark structures will soon enable us to know accurately the plants that made the actual coal, whether the bark, wood, or spores and in what proportions they have occurred. At the present time not only the land and swamp flora of the carboniferous age has been used as zonal indexes but due to the researches of Garwood, the marine algæ of that age have also been largely employed in zonal correlation.

Having dealt with the Permocarboniferous flora of Europe and North America the author refers to the Glossopteris flora of the Gondwana-land and its association with clearly marked glacial phenomena. The actual causes for such climatic changes and the probable distribution of land and water during this period are questions which still await a satisfactory solution, which will be possible only after a detailed study is made of other contemporaneous floras such as the Gigantopteris flora of China and Korea, the Angaraland flora of Siberia and the upper Permian flora of the Grand Canyon of the Colorado.

Many important results have been obtained from a botanical point of view by the study of the Mesozoic floras and these show few survivals from the Palæozoic period. During upper cretaceous times a sudden change is observable from the Mesozoic to the Tertiary Angiospermous flora. It has been suggested that the Cenomanian transgression was a factor responsible for this change according to Prof. Gordon. This suggestion is valuable and worth exploring. The study of the early Tertiary floras shows the preponderance of arborescent Angiosperms, a feature of tropical and sub-tropical climate and these plants probably migrated from the north to their present habitat.

On account of the clearly marked zonal distribution of plants to-day it has long been held that fossil plants are good indexes of climatic zones in past time. Recent studies have shown that the position in this regard is not so definite as was formerly maintained; and it is possible as Prof. Seward put it that the value of fossil plants as indexes of climate has been over-estimated. While it is no doubt generally true that plants do afford an index of climatic changes and that these changes have been very considerable in past times—the actual explanation of such changes is becoming more and more controversial. New methods of research are coming into vogue and these are discovering new links in the chain of ideas with which fossil plants have affected the Philosophy of Geology.

Zoology.

President: E. S. RUSSELL, O.B.E., D.Sc.

"THE STUDY OF BEHAVIOUR."

THE address continues the discussion begun by Dr. Gray in his Presidential Address to this section last year, *viz.*, that the organism has properties and potentialities as a whole which are not reducible to the properties shown at the chemical level. It is regrettable that the study of animal behaviour has been largely neglected in the study of general zoology, so much so that it has become the province of physiologist and psychologist "neither of whom is, as a rule, sufficient of a naturalist to appreciate the full biological significance of the behaviour observed in the laboratory". For a complete comprehension of the life processes of an animal, it is obvious that the zoologist must obtain direct information of its behaviour in the field. Interest in field study of animals is alive among both professional and amateur zoologists and one of the most significant developments of recent years has been the growth of the Oxford School of Animal Ecologists established by Charles Elton. Still in England the study of animal behaviour as a science has not taken its appropriate place as an integral part of zoology either in research or in teaching, and this unsatisfactory state of affairs is to be explained by the influence which the metaphysical doctrines of the seventeenth century exerted upon biology. Descartes who in many respects imbibed the philocopic theories of the middle ages and was at the same time under the influence of the physical and cosmological conceptions introduced by Copernicus and Galileo imposed on biology the classical doctrine of materialism with its absolute separation of mind and matter as its working method. This dualistic conception of Nature which has raised the most baffling problems with which

human mind is confronted, has diverted biology from its proper method of investigation. In their ultimate analysis, matter and mind instead of being actual realities, tend to become abstract concepts, "the product of reflective intelligence working upon the data of immediate experience". Subjective experience in certain of its aspects is a function of the organism as a whole, instead of being that of pure mind; and all objective experience is a relation between the organism and the processes or events external to the organism. According to this theory of abstract dualism, an organism is conceived as a machine with "the ghost of a mind hovering round or within it". On this basis the science of animal behaviour becomes an impossibility. The physiologist has nothing to do with mind and the psychologist finds that he can know nothing directly about the minds of organisms. Under these circumstances, the scientific study of behaviour is divorced from natural history and ceases to be an integral part of zoology.

The main business of a zoologist is not to concern himself with the metaphysical views of mind and matter, but to study animals in action, in their natural homes and haunts and in their association with other organisms. The analytical or physico-chemical method of approach is not a fruitful one, but the alternative one of treating the organism as a whole and working down to the parts represents perhaps a simpler and more direct view of living things. There is thus no such thing as living matter, the subject of physico-chemical investigation,—except as part of an organised unity. An organism is an organised unity showing the activities of maintenance, development and reproduction which are directive or purposive and in which it differs from non-living objects. In this conception of the activities of the organisms, the time factor must necessarily enter and the organism is essentially "a spatio-temporal process, a dynamic pattern in time". Viewed from this standpoint, the behaviour of all organisms is reduced to a kind of activity which does not require "mind" as an immaterial entity to explain it. The central position of the modern organismal biology is to substitute the concept of organism for the concepts of matter and mind. The organismal theory does not admit of difference between life and mind, *i.e.*, between the purely vital activities and psychological processes. The behaviour of an organism can be studied independently of its subjective experience and in this study it may perhaps be necessary to use terms of psychological implication. In attempting to analyse a total organic event or process, it may be necessary to break up the behaviour into parts, which are unreal in the sense that they are abstract and can acquire significance only when related to the whole process. It may be necessary to analyse the organic activities for obtaining a deeper knowledge, but the abstract picture so obtained has to be corrected by reintegrating the part in the whole.

The science of animal behaviour must begin with a study of the natural history and ecology of the animal. The zoologist has to find out how an animal conforms to its ecological norm, how through adaptation both in structure and activity the animal maintains itself, defends itself against enemies and procures food, and this study of habits is the basis of the science of animal behaviour. Very often a single directive activity is part of a general directive process of long range which may take months to reach its goal and in order to understand it, we may have to relate it to the general process of which it is a part. The general rule of organismal biology is that the whole life-cycle of activity must be regarded as the primary thing and the parts of it isolated for study must be integrated in the whole activity.

How is behaviour initiated? According to Pavlov the answer would be that behaviour is essentially an automatic response to external or internal stimuli. This analytical and physiological view is an incomplete explanation as has been shown by K. S. Lashley and the Gestalt psychologists, and perhaps K-Koffika's theory comes nearest to express the truth. According to the latter author reflexes are passive modes of behaviour which depend on the fact that some stimulation has taken place, while instinctive behaviour is, by contrast, significantly active in its search for stimuli. A great part of the behaviour of animals is normally response to needs and not to external stimulation, though it is true that to a considerable extent, behaviour is influenced by events in the animals' environment. The whole trend of modern work on the perception of animals establishes that they do not normally respond to simple physico-chemical stimuli but to more or less complex whole-situations. This is the cardinal point in Gestaltian theory.

The address sets out to establish two central points. One of them is that biology must get rid of the theories of materialism of the seventeenth century imposed upon it, because the metaphysical Cartisian doctrines do not accord with the modern development of sciences and are not adapted to the study of living things. The second point is that an organism is to be conceived as a four-dimensional whole or directive cyclical process and that the relation of behavioural activities to physiological is not the relation of mental to physical activities, but is relation of a whole spatio-temporal directive process to its parts.

Geography.

President: PROF. ALAN G. OGILVIE, O.B.E.

"CO-OPERATIVE RESEARCH IN GEOGRAPHY WITH AN AFRICAN EXAMPLE."

THE body of knowledge which has been incorporated in geographical literature represents contributions by workers in different fields, and geographers therefore have, in dealing with the data placed before them for synthesis, drawn conclusions from them, without possessing the opportunity of even verifying them. It is almost impossible to obtain an adequate picture of the World in all its multifarious aspects until and unless the component parts of this amazingly bewildering picture are fully represented on the canvas. Manifestly it is beyond the powers of man to be an expert in all the branches of knowledge and the geographer has to rely on the facts collected laboriously by other workers and where detailed information in any department of knowledge is wanting the observations and generalisations of geographical science must rest on insecure foundations.

The idea of collaboration in geographical research is not new. The method generally

pursued consists in the concentration upon a selected region of work by specialists in different sciences, who produce individual monographs used for the concluding geographical volume in which all the facts are linked and synthesised. Our information of Lake Balaton and its vicinity is due to such co-operative effort undertaken by the Hungarian Geographical Society in 1891, in which nearly a hundred contributors were engaged. The International Geographical Union also promotes co-operative research in various subjects, the majority of which are of a physical character. There are similar organisations such as the International Glacier Commission, the Royal Geographical Society and Sir John Murray's Survey of Scottish Lochs, engaged on promoting geographical investigations. The International Geographical Commissions deal with the problems of human geography. Types of Rural Habitation and Racial Cultures, the studies of German geographers upon settlements in the various regions of the world, have produced a mass of information most valuable to the development of geographical science: but the most striking instance of organised geographical investigation designed to be of definite advantage to national planning is that of the American Geographical Society relating to problems of pioneer settlement throughout the world.

The Continent of Africa has during the past decade received increasing interest and the information we already possess of its people, its structural and physical configuration, fauna and flora, the lake systems and the great water-ways, its natural products and climate, is bewildering. The future of the African races holds special interest and before arriving at a considered judgment, it is evidently necessary to understand the native population as they are, the life they lead, the beliefs they hold, the customs and rites they practise, their family and social organisation and their occupations and special interests. These are matters, no doubt, appropriate to anthropology, nevertheless anthropology has much to say in regard to the geographical controls and influences affecting the material life of these people and information received from anthropological studies, must be supplemented by those derived from investigations of the physical environment. The many gaps that exist in our knowledge of some of the great continents will have to be bridged by the collaboration of experts working in inter-related fields. With the object of completing our knowledge of the human geography of Northern Rhodesia, a Research Committee of the British Association was appointed and the information collected by this Committee in respect of Inter-Tropical Africa is summarised in the address.

The principal features of the body of knowledge obtained by the Research Committee are that the results were obtained within the geographical section: they represent new material contributed to the geographical synthesis of an extremely interesting region; they relate to specific localities and record the human actions together with explanations in so far as they are traceable to special environmental factors; they direct attention to a close understanding of the conditions of native's material life which, though simple, is varied. If the questionnaire issued by the Research Committee should be answered as comprehensively by the district officials in other parts of Africa as those in Northern Rhodesia have done, and if the same questionnaire were addressed to others working in South Asian Continent and adequate response received, there is every hope that our knowledge of the peoples of these vast terrestrial areas would become complete.

Economic Science and Statistics.

President: H. M. HALLSWORTH, O.B.E.

"THE FUTURE OF RAIL TRANSPORT."

WITH the introduction of automobiles and the development of coastwise traffic, the Railways are confronted with such a keen competition that their revenues are in grave danger of being permanently affected. Will the Railways be ultimately displaced? This critical position for the railway systems created by competition is universal, and forms one of the gravest problems pressing upon the nations. Since the War, partly on account of contraction of internal trade and economic depression, and partly on account of increasing competition, the earnings of the Railways have steadily fallen and the retrenchment in the railway system has thrown out of employment a large number of workers and officials besides depreciating the stocks and shares. The development of motor, coastwise and even air transport has been remarkable during the same period and the great convenience of this mode of conveyance accounts for its increasing popularity. The traffic which the Railways have lost can hardly be expected to be regained. The situation becomes piquant when we realise that the coasting trade bids fair to compete successfully with motor transport, through the evolution of Diesel-engined shallow-draught vessels capable of working into the small parts of the country, and, being fitted with the modern system of storage and unlading, can dispense with dock facilities. Perhaps the only relieving feature is that the rail traffic still holds its own in regard to transport of parcels over long distances.

The creation of an adverse position such as this is entirely due to the apathy and want of imagination on the part of the Railway companies. They did not realise the extent to which the road traffic would develop and did not adopt measures to cope with the new competitor. Complete confidence in their established position rendered them deaf to the complaints on the part of the people who resorted to the railway service, and the authorities were too slow to provide comfort to passengers and ensure safety to goods. And so long as there was no competitor, the position of the railways was unassailed but things have greatly changed. The railways have to study the needs of their customers, attend promptly to complaints by altering an existing mode of operation or the kind of service offered, even if the demands of the passenger and the trader are expensive to meet: and in this acquiescent mood lies the hope of regaining part at least of the traffic now captured by the successful rivals. It is true that the Railway (Road Transport) Acts have conferred on the Railway companies road powers, by which they are permitted to own and operate road vehicles in any district to which access is afforded by the system of the companies. The companies may feel that this liberty puts the

competition on an equitable basis, but there are other conditions and notably the age-long prejudice against them, which might still prejudicially affect their prosperity.

In the complex organisation of trade relations and the demands of the market, the distribution of traffic on an ideal basis must be baffling. The difficulties are recognised by the Royal Commission on Transport and the Salter Committee and they have pointed out that it is impossible to decide what railway services are desirable in public interests and what road traffic and coastwise shipping or what goods should in national interest be sent by rail, road, canal or ship. The ideal distribution of traffic could only be brought about if it were possible to secure that each piece of transport service, by whatever mode of transport it was effected, was charged for at a rate sufficient to cover its true cost of production. The difficulties of computing such costs are manifestly great and especially so in the case of both rail and road transport; but a formula has to be devised, in the stress of competition is to be relieved, based on the division of functions between road, rail, canal and shipping and on considerations of cost to the operator, the price to the consumer and to the community. No formula can be perfect in view of the real distinction between the cost of providing a means of communication which is of general public benefit and the cost of its use by the customer. The difficulties of getting the public to approve of any such scheme of adjustment must be borne in mind.

It would be fruitless to suggest that the great advantages conferred by road and coastwise traffic should be forfeited to the Railway companies and according to H. M. Hallsworth, the best solution is that the Railways should cease as companies and should come to be regarded as transport companies, undertaking a given piece of transport by that means or a combination of means which may appear to them as the most economic and at the same time most suited to the demands of the traveller and trader. This solution would imply the absorption of road, passenger and goods, services, and is sure to give rise to opposition. If the whole volume of passenger and goods traffic can be handled by a unified management of Transport Companies, it can be carried on on a more economic basis; this of course infers that the monopoly companies have to be maintained at a high level of efficiency. The competition, despite all arrangements, is bound to be there: the railways will also continue to provide service in cases where such service is most appreciated. It will regain its popularity if its mode of transport is economic and meets satisfactorily the increasing demands of the nation. Perhaps the experiment of bringing all the existing modes of transport under one management may solve some of the present difficulties.

Engineering.

President: PROF. FRANCIS G. BAILY, M.A., F.R.S.E.

"SOURCES OF CHEAP ELECTRIC POWER."

AT present the bulk of power in Great Britain is generated in power stations located near large cities and using superior coal, the grid merely serving as a link between these power units. At the same time there are sources of cheap power going to waste, which could be utilised if a change could be introduced in the general scheme of power production and distribution so as to utilise the grid system not merely for distribution purposes but also for collecting power wherever it can be obtained economically.

Of the potential sources of cheap power by far the most important one is waste coal which at present is either thrown away or used very uneconomically for supplying power to the mines. It is of very inferior quality and unsuitable for transport or cleaning, and can only be used profitably in pit-head stations. It represents roughly one-tenth of the total quantity of coal raised, and it is estimated that if 5 *s.* per ton is offered for this waste coal 18,000,000 tons of it with an average calorific value of 10,000 B. Th. U. per lb. would become available in Great Britain. This is 50 per cent. more than the total amount of coal used in British power houses at present.

In steam power stations installed at pit-head for utilising this coal the cost of generation would, at all power factors, be 0·05 pence per unit less than that in the largest modern stations. As the cost of generation in modern stations is about 0·25 anna per unit at 0·4 load factor, the saving is appreciable and would be greater for higher load factors. As most of the mines in Great Britain could be grouped together it would be possible to instal large stations of 100,000 kW. capacity, which could be operated very economically. Even in cases where smaller stations of 20,000 to 30,000 kW. have to be installed the cost of production would be little different from that in the larger stations because, on account of their being tied to neighbouring stations by the grid system, no spare plant would be necessary and they could be of a very simple type containing two large units. The total cost of generation (except for rates) in an actual 4,000 kW. station with 2 units operating at 0·7 load factor and using a very low grade coal at 3 *s.* per ton, containing 40 per cent. moisture and ash, is only 0·137 pence per unit.

Other sources of cheap power are also discussed. Many industries use steam at about 50 lbs. pressure which is generated in low pressure boilers. If the steam were generated at high pressure, say 350 lbs., utilised in turbines for generating power and exhausted at low pressures for industrial processes, power could be generated at a cost not exceeding 0·1 pence per unit. Thus the works could obtain their entire requirements for power at a very low cost and the balance could be fed into the grid system for distribution. Likewise, the low grade gas from blast furnaces could be used for generating power at a low cost. The cost of generation in hydro-electric stations is also discussed and it is concluded that except in the Highlands of Scotland hydro-electric power would not compare favourably with steam generation.

Regarding the cost of distribution, since the population in Great Britain has gathered to a large extent round the coal fields and there are practically no towns, except the sea-ports, that do not lie within easy reach of them, nearly two-thirds of the population would be within 40 miles of the coal fields and the cost of transmission from pit-head stations at 132 kV. (estimated at 0·02 pence per 100 miles at 0·4 load factor) would be less than 0·01 pence per unit.

Consequently, generation in pit-head stations would result in an economy of 0·05 pence per unit as compared with generation in the large power stations located near towns. A plea is also made for the reduction of the municipal rates which are exorbitant and often amount to 0·1 pence per unit, which is of the same order as the cost of coal. If this is reduced to 0·05 pence there would be a further saving of 0·05 pence, and the selling price of energy could be reduced by 0·1 pence. Since the present selling price for domestic heating is only 0·5 pence per unit, a reduction amounting to 0·1 would bring in considerable additional domestic heating load. Similarly, a considerable improvement in the railway and metallurgical load may be expected from a reduction in the selling price. As the load increases, there would be a corresponding improvement of the load factor and the density factor, resulting in a reduction of the cost of generation and distribution, and a further reduction in selling price of energy would become possible. Thus, the process once started by the reduced prices due to the utilisation of sources of cheap power and a reduction in the burden of rates would gradually gather strength and put the electric supply industry on the road to considerable development.

It is not proposed that these new supplies should be introduced suddenly and the present power stations replaced by pit-head stations, as that would involve the loss of considerable central station capital, but it is suggested that full advantage should be taken of the facilities afforded by the grid for the collection of power wherever it becomes available at a low cost, and a new policy should be planned out, so that the change can be introduced gradually as the electric supply industry develops. The present rate of expansion indicates that in ten years' time the station power will be at least double of its present figure. This normal growth together with the closing down of the present small stations will give opportunity for a large-scale trial in a few years, while every improvement in methods of electric transmission of power will place the pit-head station in an increasingly stronger position for supply to large towns.

Anthropology.

President: CAPT. T. A. JOYCE, O.B.E.

"THE USE AND ORIGIN OF YERBA MATE."

THE subject of the address may seem at first sight to be a little removed from anthropological studies, but from the standpoint of the President, an exposition of Ethno-botany is of the highest importance. The wide-spread use of stimulants, narcotics and food plants throughout the world has an important bearing on culture diffusion and in a large number of cases, the spread has been so rapid that the original home of the majority of "drugs" and "drinks" is lost in obscurity. The cultural basis of foodstuffs is not widely appreciated; they affect profoundly the ideals of the people, their general outlook on life and the events and processes of the objective world and in their relations with other nations. The consumption of purely vegetable diet seems to favour subjective idealism and metaphysical subtleties, suppressing instincts of enterprise and capacities for colonisation. On the other hand, a meat diet would appear to promote a more practical type of religion, love of freedom and open air, and a restless energy which manifests itself in expansion and conquest.

The term *maté* originally denoted a gourd or silver cup in which the decoction of the leaves and shoots of the plant *Ilex paraguayensis* which is indigenous to Paraguay and Southern Brazil, was prepared, and the word is now transferred to the drink which is drunk through a tube known as *bombilla*. The origin of the practice of infusing the leaves of *ilex* is very obscure. The earliest mention of the drink is found in a book by Nicolás Durán, a Jesuit missionary in Paraguay (1626-27), by which time the beverage had become popular throughout South America. Although the Spanish occupation of South American states dates from 1516, and acute observers such as Ulrich Schmidt, Cabeza de Vaca, Sao Francisco, Nicolas Monardes and Diaz Guzmann, who travelled in the occupied territory and have left interesting records of great ethnological importance, have made no reference to the use of *Yerba maté*. Pinelo writing in 1636 refers to an author Robles Cornejo where he says a full account of the herb is given; and Cornejo's work probably was written in 1617. So far the evidence available would seem to show that the drink is probably a native discovery developed and elaborated by the Jesuit missionaries who settled among the native population. But according to Monardes and Conjero it would appear that the use of the leaf of *ilex* was unknown to the natives prior to the establishment of Jesuit missions, except perhaps for chewing.

As regards the properties of the *ilex* which have won for it so widespread a popularity, it is supposed to contain all the active alkaloids of coffee and tea together with an aromatic oil and gluten. The effects of *maté* on the human system and the modes of preparing this beverage have been described in great detail by Nicolás Duràn and Nicolas del Techo. The discovery and popularisation of this drink in South America are closely associated with the history of Jesuit settlement in that continent from 1609 upto 1774 when the reservation was added to Crown properties. By this time *ilex* had become much an important article of local industry and export that in 1807 the profits derived from it amounted to £ 100,000 annually.

It has been suggested that the native name of *ilex, Caa* which is only a generic term for tree, has some relation to the Chinese C'ha meaning tea in Pekinese, Mandarin and Cantonese dialects. Tea was first brought to Europe by the Dutch in the early seventeenth century from Bantom whither it was imported by Chinese merchants from Amoy where it was called Tê. The first mention of tea in Western literature is in Maffei's *Historica Indica* published in 1558. It is not inconceivable that the Jesuits of the period, looking for a substitute for tea which was by then introduced into Southern Europe, also introduced the Chinese word which was mispronounced by the natives. The missionaries encouraged the use of the leaves of *ilex* among their Indians to whom it was served out with rations, probably with a view to wean them from indulgence in intoxicating drinks. They succeeded in building up a most flourishing and lucrative industry before they were expelled and its condition in the first half of the nineteenth

century is vividly described by J. P. and W. P. Robertson in their "Letters on Paraguay". The development of the *Verbales* or *ilex* plantations by the Jesuits is interesting. The economic importance of the leaf combined with the fact that the tree grows in inaccessible swampy mountain valleys, led to the inception of efforts to bring it under cultivation. In the wild state, the tree is propagated by birds which eat the seeds and digest their gluten envelope; and seeds which have passed through this process of preliminary digestion germinate and grow better than the trees attempted to be raised by planting the seeds without stripping them of their gluten coat. The groves planted by the Jesuits in their communities were extensive, consisting of hundreds of thousands of trees, and from this one may easily judge the extent of the economic importance attached to the industry and the rapidity with which the use of the beverage was spreading.

The address is intended to excite the interest of young men trained in Botany in the bearings, that their studies in economic aspects of the science, have on the cultural history of the peoples of the World.

Psychology.

President: SHEPHERD DAWSON, M.A., D.Sc.

"PSYCHOLOGY AND SOCIAL PROBLEMS."

SOCIAL problems are partly material and partly mental. Great progress has been made in the solution of material problems; the investigations of the physical and biological sciences have given no increased control over material resources; the energy values of foods have been ascertained and the amounts required for doing works of different kinds satisfactorily and efficiently, have been determined; diseases have been brought under control and generally national health has greatly improved. Comparatively little attention has been paid to the mental aspects of social welfare and we have no accurate data concerning the distribution of intelligence and aptitudes among the people, the predisposing causes of idiocy and other forms of mental deficiencies and the mechanism of inheritance by the offspring of the strong and weak points in the parental character. It is manifest that for a proper understanding of the numerous problems that arise from life in a community and for national planning, the social, economic and political studies are just as important as those of human mind. The solutions to the mental problems are to be found ultimately in the forces which move men to action in their inherited capacities, in their acquired characters, in the mentality of the groups to which they belong and in their organic relationship with such groups. We do not possess accurate scientific data in respect of the number and nature of innate human tendencies and their operation in or influence on social life or how these tendencies affect personal behaviour. There are observations and speculations on this topic, but they lack the objectivity and precision which science demands. Racial inborn tendencies in the children are of great social importance for practical life because their future education has to be built on them: therefore our knowledge of their potentialities, how they are evolved and how they express themselves in action, must underlie all educational endeavour.

Social problems can be investigated either from the point of view of the individual or from that of the group to which he belongs. This investigation must not be, however, exclusive, but complemental, for the problems of the individual are also the problems of the society, however complex the social group may be. The social problem or the educational problem must at all times be how to fit the individual to the social structure and the group to the individual. The solution to this problem demands some knowledge of the natural endowments of the individual, the practical and intellectual heritage of the group and of the methods of making the most by their mutual interaction. In attempting to assess scientifically the natural endowment of an individual and social achievements, it is clear that a distinction is to be recognised between human ability and capacity. "Ability is actual, capacity is potential." A satisfactory measurement of ability or capacity must always be difficult on account of the adaptability of the human organism and the best of examinations can only give us a blurred picture. The conditions of chemical and physical laboratories cannot be reproduced in the investigation of human and social phenomena: we can obtain only approximations to these conditions. All kinds of capacities are tested in psychological laboratories with varying success and it may be possible at some future date to evaluate the facts with some approach to accuracy with which physical characters can be assessed. What is needed is more extensive and more co-operative work. The results already gathered have a great social significance. They have been obtained from extensive studies of children of all ages, races and grades of society and they may be used in getting a fairly reliable information regarding the distribution of intellect in a given population as a whole and the various professional, social and economic spheres, and its bearing on the fertility, disease and reactions to environmental conditions. They point to a method of getting reliable information which will throw light on the puzzling problems of mental inheritance and on the manner in which the educational wastage can be turned to best account both for the individual concerned and the society.

In the investigations into the inheritance of intellect much reliance has been placed on the empirical methods based largely on social and professional success. These enquiries have yielded very often tantalising results; successful and enterprising parents are not as a rule blessed with promising children, who sometimes come of parents obscure and even defective. The theories of genetic inheritance which have proved so fruitful in the investigation of the physical characters of plants and lower animals, are capable of being applied to human anatomical and physiological characters, such as the colour of the skin, hair and eyes, stature and susceptibility to disease, and it is probable that they apply also to mental characters. The difficulties in all investigations into the structure and potentialities of the mind, must be those relating to the control of the environmental factors, the designing of satisfactory tests for adults and the isolation and definition of simple mental characters. Investigations into all these fields necessarily depend upon the co-operation of psychologists, teachers, experimental

biologists, medical men and statisticians in so far as the study of mental inheritance resembles that of most other social problems.

Educational Science.

President: H. T. TIZARD, C.B., F.R.S.

"SCIENCE AT THE UNIVERSITIES."

(Some Problems of the Present and Future.)

SCIENTIFIC education and research have introduced in modern life social amenities, economic progress, transport facilities, better health and wider opportunities for interesting and useful work, such as few could have visualised half a century ago. Even a politician believes in scientific research but all who talk about it do not necessarily understand its full connotation and implications. The agreed educational policy in all enlightened countries is that scientific studies should receive greater emphasis than the humanities and it is obviously of great advantage to the state if all its citizens have received training in some form of scientific studies. However, it is not quite clear what exactly we mean by a general scientific education. There is bound to be disagreement when we come to define the extent and character of scientific studies in the curricula of secondary and intermediate stages of education. Moreover, how is it possible, in a few years, to give the pupils an adequate insight into the beauties and wonders of the physical and biological sciences or to convey a conception of the law and order in the universe and an appreciation of the discipline and method of research, without running the risk of leaving them with a mere smattering of uninspiring knowledge. Our experience of scientific teaching in the schools is too recent and insufficient to be able to deduce any generalisation and the experiment tried in a number of ways and in different kinds of schools needs sympathetic encouragement. The general growth in the teaching of science in the secondary schools has naturally been accompanied by a great increase in the number of young men electing scientific courses of study in the universities. This growth is rendered possible by provision of public money, and it is estimated that the public expend in one way or another nearly £ 200 a year on each student of science, with the possible exception of students at Oxford and Cambridge, who are more richly endowed from private sources. The provision of public revenues for educational purposes imposes on the teachers and members of the administrative staff the additional responsibilities which create for them the position of public Trustees who have to examine the expenditure more scrupulously and have continually to ask whether additional expenditure can be justified and whether the public gets in return the value for supporting the educational institutions. Perhaps in the middle ages when the economic stress was not half so keen as it is in modern times and the demands of the society were less complex and numerous, the educational adage "knowledge is its own reward" might have been accepted by the public, but the conditions of life in the present age are entirely different and in some measure the educational institutions must assume the responsibility of training the mind of young men without neglecting the training of the hand and make them sufficiently resourceful to enable them to attack with confidence and success the new problems that are perpetually arising in the rapidly changing world.

The present tendency of scientific education in the universities and schools is to produce experts with a corresponding impoverishment of other faculties of the mind. There are other things besides science in life and the variety and richness of a community have to be adorned by knowledge other than that which belongs to Physics, Chemistry and Biology. Specialisation for many must necessarily imply ignorance of each other's general interests: it is doubtful whether it enables the expert to live a full and rich life of usefulness to himself and to the society of which he is a member. What the world of knowledge might gain must be presumed in cases of overspecialisation as a gain to the society as well. Nevertheless specialisation cannot be for all and in the attempt to reach it, many a career which may otherwise be successful, is practically ruined. All University Education in science is designed primarily to train the young men for learned professions; a few graduates in science break adrift and turn with success to other occupations such as law, administration, journalism and so forth, but rarely politics. A hundred years ago it was not difficult for a scientific man to follow in detail the work of others: now it is as much as a specialist can do to keep abreast of the progress of knowledge in the particular field in which he is interested. It is impossible for anyone to study science in the University as a general education, as men study classics, history and philosophy.

During the present century there has been a wide and incessant demand for scientific education and scientific research owing to the increasing recognition of the fact they are the foundation of national well-being and prosperity. Scientific discoveries have altered the face of society throughout the world and even an administrator often finds himself in situations where a little scientific training would serve him in good stead. It is true that accumulation of scientific knowledge is bewilderingly stupendous, but the tendency on the whole has been to make the general principles and methods more clear and easier to grasp, because the several parts of this structure cohere well into one unit. A scientific training will be all the better if it is made to include the study of the historical and philosophical background of science. This little reform will render clear to the youthful minds the law and order in the universe and make them realise that scientific training is organised discipline of the mental faculties and scientific research is only a quest of truth and the spirit of all scientific studies is service to humanity.

Agriculture.

President: J. A. S. WATSON, M.A.

"SCIENTIFIC PROGRESS AND ECONOMIC PLANNING IN RELATION TO AGRICULTURE AND RURAL LIFE."

ALMOST from the earliest times, improvement in agriculture has determined the progress of the human race. The progress may be one of increase in numbers or rise in the standard of living. The population has increased enormously in many parts of the world, but in others,

especially in some of the Western countries, it has remained more or less static. The address deals with some of the problems of the latter.

Contrary to the predictions of Malthus and others, agricultural production has increased enormously in recent years. The opening up of new areas in different parts of the world, increased yields through use of improved strains and application of chemical fertilisers, reduction in cost of labour through introduction of new mechanical devices, better facilities for transport and marketing—all these have led to excessive production and consequent fall in prices.

The present position, which might have been hailed at other times as most desirable, has only brought on acute economic distress to the farmer whose position has become increasingly unendurable. Various expedients have been devised to improve his lot and to ensure his getting a fair return but most of them are only of the nature of palliatives and do not touch the root of the trouble. Sound economic planning of farming practice is the only means of avoiding the inevitable neglect of agriculture and consequent rural depopulation. This would, no doubt, be very difficult to carry out, but the situation should, nevertheless, be faced in the proper scientific spirit. The agricultural possibility of each area should be carefully investigated with special reference to the demand for the produce and the return that may be expected. Wherever possible, cheap mechanical device should be introduced and human labour so allotted as to ensure maximum output through intense specialised knowledge. The holdings should be greatly enlarged and the scope of production considerably widened. With organization of "factory farming" of this type, it should soon be possible not only to relieve the present situation but also to ensure a happier and more contented rural life.

SUPPLEMENT TO "CURRENT SCIENCE".

Reviews.

NATURE AND LIFE. By Alfred North Whitehead. (Cambridge. Printed by W. Lewis, M.A., at the University Press, 1934, pp. 96.) Price 3*s*. 6*d*. net.

Brilliant scholarship adorns the pages of this little book. It comprises two lectures which the author delivered before the University of Chicago in October 1933 and the University possesses copyright in the United States of America. Dr. A. N. Whitehead has attempted in these two lectures to correlate the World of Science with the worlds of religion, art, letters and morality with the object of establishing that Nature itself has processes, goals, beauty and values.

Descartes' influence upon European thought was profound and continued for the last two centuries. His bifurcation of Nature into matter and mind has raised intricate problems in science. As to its effect on philosophy, Professor Whitehead writes as follows:

"The seventeenth century had finally produced a scheme of scientific thought framed by mathematicians for the use of mathematicians....The enormous success of the scientific abstractions, yielding on the one hand *matter* with its *simple location* in space and time, on the other hand *mind*, perceiving, suffering, reasoning but not interfering, has foisted on to philosophy the task of accepting them as the most concrete rendering of fact. Thereby modern philosophy has been ruined. There are the dualists, who accept matter and mind as on equal basis, and the two varieties of monists, those who put mind inside matter and those who put matter inside mind. But this juggling with abstractions can never overcome the inherent confusion introduced by the ascription of misplaced concreteness to the scientific scheme of the seventeenth century."

These thoughts find a fuller exposition in "Nature and Life". The main doctrine of Professor Whitehead is that neither physical Nature nor life can be understood unless we fuse them together as essential factors in the composition of "really real" things whose interconnections and individual characters constitute the universe. The modern conception of matter and mind is that they, in their ultimate analysis, are imperceivable; we only perceive relations or events. The "mind" is conceived as an extended, immaterial thinking entity. If "life" were defined as a "spatio-temporal" process, the definition of "matter" cannot be fundamentally different. Our notion of "soul", "life" and "mind" must at all times, whatever may be the progress of scientific analysis and philosophic thought, remain vague, much more vague than our idea of "matter". Consciousness both of self and of "relations" and "events",—a distinctive property of life,—is far too elusive. Its power and characteristics seem to be limited, however, by "mind" through which it functions. These are problems which have perplexed the scientists and philosophers.

This little book is an able exposition of the doctrine of realism and is a most stimulating contribution to modern philosophy.

LIFE AND LIVING: A SHORT STORY FOR CHILDREN. By E. P. PHILLIPS, M.A., D.Sc., F.R.S. (S.Afr.). (L. Reeve & Co., Ltd., Lloyds Bank Buildings, Ashford, Kent, England. pp. xiv+152, 1933.)

This book is worthy to be read not only by children but also by the educated adults. It is true that the book is intended to be an elementary treatise on Biology, but the amount of information contained in it is surprisingly full and varied. Every pupil in the High School ought to possess a copy of it and we have no doubt that he or she will read it with profit, diligence and enthusiasm.

It is obvious that every person ought to know something about the fundamental facts and phenomena of life which will give him an insight into his position in the scheme of things and on which the art of living depends. Children should at an early stage be introduced to the truth about life and about themselves. The book is written in a way that any parent who is himself intelligent and resourceful, can hold talks with his children on problems of sex, population, heredity and other topics of great social and scientific interest and about which there is any amount of senseless prudery.

There are twenty-two chapters. The topics have been carefully chosen and treated with great clearness and accuracy.

Chapters XIX and XX deal with the teachings of the great prophets and of religion. We cannot go through life like perpetual blisters and religious ideal is something worth living for. The world around impresses on the mind of children with wonder, awe and mystery and later in the course of proper scientific education, they are bound to discover law, order and directiveness in the phenomena and processes which it is the purpose of their studies to explain and elucidate. If a scientific outlook is indispensable to every educated citizen for discharging his civic duties, a religious spirit is equally necessary for his right conduct in social relations. The steadying influence of discipline which religion (not dogmas) imparts to character, is still the pivot of all human institutions, and its educational value is not to be minimised. Chapter XXI is devoted to the consideration of moral conduct. Of course the moral sense is capable of being developed through scientific instruction, but for its consolidation, the assistance of religion may also be invoked. The earlier chapters treat of the fundamental facts of biology in a simple and clear style.

The book is a chaste one. Every boy and girl ought to read it. Most of the illustrations are self-explanatory and vivid. The book is to be provided with an index which it lacks for the present.

EARLY FORERUNNERS OF MAN: A MORPHOLOGICAL STUDY OF THE EVOLUTIONARY ORIGIN OF THE PRIMATES. By W. E. Le Gros Clark. (Bailliere Tindall and Cox, 7 & 8 Henrietta Street, Covent Garden, London, pp. xvi+288, 1934.) Price 15*s*. net.

Zoologists and physical anthropologists will find this book invaluable in the study of the evolution of the primates as offering an estimate of the real position of man in the zoological scale. We can hardly form a correct concept of man's phylogenetic origin, without a proper perspective of the evolutionary development of the whole order of primates. While there is a general acceptance of the thesis that man is descended from some lower forms of life, there is by no means unanimity of agreement among biologists as to the exact line by which he attained his present status. Any comparison with the higher apes will only reveal similarities of anatomical structures which alone will be inadequate for establishing human phylogenesis, for they represent the culminating points of the divergent trends of the evolutionary process. The question of relationship of man and his precise position in the group of primates is to be investigated from the standpoint of the evolutionary development of the primates as a whole. The evidence in favour of genetic relationship is derived from the investigation of the data obtained from anatomical, palæontological and embryological researches and the book under review deals mainly with the morphological aspects of the study. The evidence which palæontology and embryology offer, though in the present case it may not be abundant, throws clearer light on the actual lines along which evolutionary development has progressed. At present we have to rely more on the evidence furnished by comparative anatomy of the existing forms and also of the fossil remains recently discovered.

In the scheme of classification adopted by the zoologists, man is placed at the head of the sub-order Anthropoidea, which is distinguished by a definite assemblage of characteristics such as a capacious skull, the forward position of the eyes, the mobility of the facial muscles, the use of fore-limbs as a grasping organ, flat nails on the phalanges and the absence of muffle. The family Hominidæ is closely allied to the family Simiidæ which includes the tailless apes. The structure of the human body is fundamentally like that of the higher apes and there is hardly any detail of structure in human anatomy that is not represented in the latter, although the assumption of an erect posture by man has resulted in characteristic specialisations of the pelvis and viscera, the fore-limbs and the foot. The "brain" is the most exclusive possession of man, exceeding in relative bulk that of any ape and in function surpasses them all. Still, the structural and functional relationships are all parallel. The book is devoted to a critical examination of the evidence of skull, teeth, limbs, brain, sensory organs, alimentary system and reproductive organs. Chapter X deals with the relationships of the insectivora with primates. The tree shrews (*Tupaioidea*) in many of their features resemble the primitive primates so closely that some zoologists have deemed it legitimate to remove the family *Tupaiidae* from the group Insectivora and include it among the primates. In view of the increasing bias in favour of such an inclusion, the book devotes considerable space to examine the

anatomical evidence for such a procedure. This evidence leads to the conclusion that the tree shrews are more primitive than even *Prosimiae*, but on the other hand if the fossil forms are taken into account especially with reference to *Anagale*, *Plesiadapids* and the early *Notharctinae*, it becomes evident that the structural gaps of the existing forms vanish. The last chapter of the book on the Evolutionary Radiations of the Primates deals with the problem of the degree of parallel development undergone by the various groups of primates after their early evolutionary segregation and separation from the common parent-stem. In this chapter the evidence of the various anatomical systems are collated and synthesised in order to provide a comprehensive picture of the phylogenetic history of the primates. The phylogeny of the primates commencing in an ancestral form of lemuroid type, has diverged along four or five lines of evolutionary development, culminating at successive levels in the modern lemurs, Tarsius, Platyrrhine and Catarrhine monkeys, anthropoid apes and man. The living members of each group must be recognised as the few survivals of a whole series of evolutionary radiations which diverged from the beginning from a generalised stock of placental mammals, and which developed evolutionary potentialities of their own in diverse directions.

This book is undoubtedly a valuable contribution. It gives us a clear and comprehensive account of the recent researches into the comparative anatomy and palæontological materials of the primates. Zoologists and Physical Anthropologists will find in the book a mass of information arranged in a cogent and logical fashion, which they will have to search otherwise, among original papers, scattered in a number of journals and magazines. As usual, bibliographies are given at the end of each chapter. Le Gros Clark undertook a great task and deserves warm congratulations on its successful and satisfactory termination.

THE CAUSES OF EVOLUTION. By J. B. S. Haldane, F.R.S. (Longmans, Green & Co., London, New York, Toronto, 1932, pp. 215.) Price 7*s*. 6*d*. net.

The book is based on a series of six endowment lectures delivered in January 1931 at the Prifysgol Cymru, Aberystwyth, founded by the munificence of the Davies family. One of the conditions of the endowment is that the substance of the lectures is to be published in book form. Professor Haldane devoted these lectures to "A Re-examination of Darwinism". In the preface to the book, the author advises readers who are not acquainted with the general principles of biology to skip slightly over Chapters II and III which give a comprehensive summary of the recent developments in the field of genetics which he uses in support of his argument; and the mathematical interpretation of the problems of variation contained in the appendix will appeal only to a limited section of biologists. The greater part of the approach to the subject is through the mathematical route and the use of calculus is becoming increasingly indispensable for obtaining a clear concept of the possibilities and direction of variation and the limits of their inheritance. It is, however, difficult to suppose that the rigorous quantitative methods of the physical sciences are suitable for researches in biology, even in the case of genetics. Within recent times the statistical and metrical methods have been employed with considerable success in the elucidation of the obscure problems of heredity. The results can be measured. The causes are brought under experimental control. They give us an insight into the processes taking place in Nature and, in some measure, the extent and character of differentiation can be predicted. The application of mathematics to biological investigations first introduced by Pearson and his colleagues has tended on the whole to become more general as a convenient and useful method in dealing with the numerous data on the inheritance of structural variations and other continually varying characters of organisms.

In view of the persistent and voluminous criticism to which the Theory of Natural Selection has been subjected since its definite formulation, it is not surprising if a few biologists and the educated public have lost faith in it. Since the days of Darwin and Wallace, great changes have occurred. The increasing perfection of microscopic technique, the establishment of new schools of biology, the accumulation of more precise data furnished by researches in Palæontology, comparative anatomy and embryology and the formulation of fresh causes of evolution, must be partly responsible for unsettling the confidence of biologists in Darwinism. The evidence from palæontology and

from modern rare species is often contradictory. The Geological record must naturally be imperfect, for the species rare in their own day have not probably left any traces behind them. Moreover, plants do not provide satisfactory evidence of perfectly continuous evolution.

The introductory part of the book gives a frank and faithful account of the present position of Darwinism together with an exposition of the evidences and causes which have been advanced as the result of modern investigations both in its support and refutation. This preliminary survey renders the ground clear for an impartial estimate of the facts. In the subsequent chapters, the following questions are answered: "What is the nature of heritable differences within a species? Are the differences between species of the same or of a different character? Does Selection really occur in Nature? If so, will it account for the formation of species? Must we allow for other causes of evolutionary change?" Finally, after surveying the process of evolution, the author proceeds to ask what judgment we have to make about it. "Is it good or bad, beautiful or ugly, directed or undirected?" Such questions have a philosophical flavour and the answers may not come within the province of science. But the interests of the society are largely concerned with the answers to such questions.

The author occupies a position different from that of speculative and experimental biologists and can write on the subject of natural selection with authority which does not belong to the latter, for he is "One of the three people who know that most about its mathematical theory". Apparently out of consideration for his less mathematical brethren, the mathematical theory of natural selection is treated in the Appendix and printed in small type; but the passion for mathematics is so irrepressible, that in practically every chapter, the reader is treated to mild doses. The second chapter of the book dealing with variation within a species gives an illuminating summary of all the cases of inheritable factors due to Plasmon, Mendelism (single and several genes and their order in a chromosome) and the addition of one or more whole sets of chromosomes. All hereditary differences which have been investigated fall under one or the other of these categories. The new genes themselves arise from time to time by a process called mutation whose importance for any account of evolution is clear. It enables us to escape from the impasse of the pure line. Many of these facts which have been added to our knowledge by experimental biologists were unknown to Darwin. The general conclusion is that interspecific differences are of the same nature as intervarietal. The latter are due to a few genes with relatively large effects and rarely are due to differences involving whole chromosomes. The reverse is true of differences between species. The present position is that we know and can say more about Evolution than was possible in the days of Darwin and further progress in our knowledge depends upon the accumulation of facts concerning variation and selection.

The book is a clear and logical exposition of the possible causes of Evolution, and few can wish for a better book. The outlook is fresh. The use of technical terms is limited, without sacrificing the sense. The thoughts are pregnant and stimulating. The book will always rank as one of the first-rate contributions to the large body of literature on evolutionary biology.

THE BOOK OF SCIENTIFIC DISCOVERY: HOW SCIENCE HAS AIDED HUMAN WELFARE. By D. M. Turner, with a Foreword by Professor Charles Singer. (George G. Harrap & Co., Ltd., London, Bombay and Sydney, 1933, pp. 259.) Price 7*s* 6*d*. net.

All human institutions, like organisms, have a life-cycle and their progress and enlightenment at any stage of their history must be a measure of the scientific knowledge attained by their members. Science is part of the structure of the modern society and the achievements of the former are the decorations of the latter. So great are the changes in the daily life of man that he has scarcely time to adjust himself to the new conditions.

The history of the achievements of science and their incessant application to the practical needs of society must be fascinating. Dr. Turner has, in this book, traced the progress of science, in its relations to social change and in relation to human welfare. She tells of Leonardo da Vinci and Galileo, whose work commenced a new epoch in experimental science. Harvey and his work and the age of Newton are reviewed. The introduction of steam power, the industrial revolution, the effect of science on social conditions, the development of the knowledge about electricity, the researches in

medical and social sciences and the steps taken to usher in the modern scientific results are treated fully and clearly.

We can understand the spirit and the outlook of science only when we are acquainted with the evolutionary history of its output. Scientific knowledge cannot get away from traditions. If science has progressed far more rapidly than any other body of knowledge, it is all the more reason for a scientific worker to be acquainted with something of the conditions of its change and development. There are fourteen chapters in the book. Commencing with the characteristics of mediæval thought and the early alchemists, the reader is taken to the different phases of the development of scientific knowledge till in the final chapter he is told of the position that science occupies in our life to-day. A survey of the era of progress has an interest and educative value of its own. The subject-matter is treated in such a way that any chapter can be studied independently of others and yet all the topics when read together fit into one another so as to form a homogeneous unitary picture.

A book of this description is indispensable to students of science. The knowledge that is imparted in the schools and colleges in the name of science is neither inspiring nor interesting. It lacks the historical background so necessary for a proper appreciation of the pioneer work that has preceded. Some of the original drawings of the anatomical preparations of early scientists like Leonardo, Vesalius and Harvey are given as also of the early apparatus used by them. There is liberal education in this book.

THE ROMANCE OF RESEARCH. By L. V. Redman and A. V. H. Mory. (The Williams and Wilkins Company, Baltimore, in co-operation with the Century of Progress Exposition, pp. x+149) Price $1·00.

The authors have tried to place before the general reader a lucid exposition of the way in which man has acquired mastery over the forces of Nature. A perusal of the book cannot fail to produce in the mind of the public a deep sense of gratitude to those scientists who have by their patient industry and research contributed to the material progress of the society. It is true that there is many a slip between the successful discovery of a principle and the practical application of it to the industries. Perkins was no doubt the first to recognise the potentialities of coal, but it was reserved for the German chemists to extend and exploit his discoveries for the manufacture of the by-products which have profoundly altered the completion of industries. In Beckland we have the case of discovery again of a principle, but it was reserved to him to utilise it for the practical problems.

The book gives a picture of the progress of civilisation through scientific research; and the latter must necessarily include an account of the method, development and achievements of scientific workers. This account is spread over twelve chapters. The greatest lesson which the book sets out to emphasise is that the period of industrial and economic depression is precisely the time when greater investment of money is urgently required to promote fresh scientific research so that the new knowledge might be utilised for establishing new industries and strengthening the old. This lesson like most lessons in life is difficult to absorb. To students of general science, the book furnishes a historical background which will amplify and render clear the knowledge of text-books. They will welcome the book as a useful addition for supplementing their knowledge of scientific methodology. The general reader will find in the book both interest and profit. The progress of science is romantic. It is full of thrills, disappointments and achievements. The contribution of science to the cultivation of intellect is great, but its contribution to the building up of the present-day civilisation is greater. The book records the impressive march of human needs and their supply, hand in hand. To a reflective philosophic mind, the thought "whither are we tending" must naturally occur after the perusal of the book. The book is at once refreshing and stimulating.

OCEAN WAVES AND KINDRED GEOPHYSICAL PHENOMENA. By Vaughan Cornish with Additional Notes by Harold Jeffreys. (Cambridge, at the University Press, pp. xv+159.) Price 10s. net.

The book represents the fruits of what one may call the labour of love. Dr. Vaughan Cornish went far and wide in quest of his material and he has summarised his observations in these words, "I have never again had a house with such a view as that from my former home on the cliff, but I have compensations in the memory of many wonderful sights of storms at sea; of snow

waves moving in ghostly procession across the Canadian Prairie; of sand waves, rank behind rank, driven by the desert wind; of the onset of the tidal bore in the Severn and the Trent, and of Leaping waves in the Rapids of Niagara." These phenomena are essentially hydrodynamical and therefore part of Physics. For a proper understanding of the subject, the facts collected by Dr. Cornish need to be examined both from the observational and from the mathematical standpoint. No other previous worker has gathered material so extensive and varied as Dr. Cornish has obtained on the subject and in the chapters contributed by him he makes a number of remarks on the theoretical considerations, both quantitative and qualitative. The Additional Notes provided by Dr. Harold Jeffreys of St. John's College, Cambridge, are intended to supplement the work of Dr. Cornish and their interest to navigators, engineers and physicists in general must be obvious.

The first chapter of the book commences with a description of the stormy weather which overtook the ocean in December 1911 and from the promenade deck on board the Liner "Egypt" the author calculated the theoretical wave-length and the speed of the waves and the relation of the latter to the velocity of the wind, from the "period" time interval between successive wave crests, by the application of the well-known formula. He found that when the sea was heaving heavily, the theoretical wave-length for the period of 13·5 seconds, was 934 feet and speed of the swell being 47·25 miles. This chapter discusses how to determine the height of ocean waves from ships on their course, the sea room required for the full development of waves, the steepness of waves on oceans, inland seas and lakes, and concludes with an account of the reaction of ocean swell upon the wind. A practical point affecting meteorological records is indicated as arising from the observations, *viz.*, the direction of the curl on the waves or in other words, their direction of breaking, is in fact the resultant of wave and swell, so that the general run of the waves provides a more reliable index of the direction of the wind. The second and third chapters deal with waves in sand and snow formed and propelled by wind and current, and tidal bores and other progressive waves in rivers.

The book will always be found invaluable to navigators, Royal Marine Engineers, meteorologists and students of Physics. It is eminently readable and the subject-matter is treated in a simple and elegant style. The illustrations are superb. There is a short selected list of original contributions by the author upon waves and allied phenomena.

GEOGRAPHY OF NORTH AMERICA. By George J. Miller and Almon E. Parkins. (John Wiley & Sons, New York, Inc., Chapman & Hall, Ltd., London, 1934, pp. xviii+621.) Price 28*s*. net.

We have before us a typical text-book, beautifully illustrated and attractively got up. Every geographical topic is adequately treated and every aspect of human problem is considered from the standpoint of the environmental factors and resources available for promoting its expansion.

The history of the remarkable development of North America since its occupation by the white man must always form an extremely remarkable chapter of the general progress of human civilisation. The commanding position which the wealth of the natural resources of this great continent has given to its people in the international, political and social affairs of the world is likely to become greater in the future, in consequence of the increasing exploitation of the means for its augmentation. The potentialities of North America are almost limitless and the genius of the Americans for their utilisation is also equally great. The whole theme of the book is how the colonisation of America stimulated the natural desires and ambitions of the early occupants and how they made use of the assets of the new country. The outcomes of such endeavours must be naturally reflected in the social, political and economic organisations of the people and the history of these institutions forms an interesting chapter of the book.

The population problem of North America has a peculiar interest. There is the indigenous civilisation super-imposed by a more virile European culture and a large body of imported negroes with the consequential hybrid population. Questions such as the rights and obligations of citizenship and acquisition of property, which must emerge in an acute form sooner or later, have to be foreseen and answered in a manner which would avoid ugly developments. The greatest density of population is in the belt connecting Boston and Pennsylvania through New York—a strip of country where the conditions are highly favourable for man

to make a living through commerce, manufacture and transportation and financial transactions. Since 1930, the population curve is on the horizontal and restriction of growth is due to the general practice of birth-control methods. Whether limited population is a mark of national prosperity is a question which each country must answer, though it is true that the fitness of a continent is best measured by the number of people it can support. Theoretically it is true that the population growth should not exceed the limits of the sustenance power of the country, but have we any reason to think that our improvements have reached a stage beyond which they cannot proceed? The checking of soil erosion, careful selection of seed, the adaptation of crop to soil and climate, the breeding of new varieties of crops, the introduction of new plants, better methods of tillage, the improved methods of the application of manures and fertilisers, the proper and adequate supply of water for irrigation, the improved methods of cattle-rearing, poultry and pig farming and the exploitation of fisheries must provide work, food and habitation for the overflow of population from the industrial and manufacturing centres.

The book is a fine example of what geographical treatises ought to be. Every topic is discussed adequately and critically and every chapter concludes with a set of stimulating questions, problems and exercises. A complete list of reference books for library work is given for the students. Politicians and economists will find in this book as much guidance in national planning as students of Geography will find matter for obtaining a conspectus of the amazingly intricate problems of the North American continent.

PRINCIPLES OF HUMAN GEOGRAPHY. By Ellsworth Huntington and Sumner W. Crushing. (John Wiley & Sons, New York, Inc., Chapman & Hall, Ltd., London, 1934, pp. xxii+453.) Price 18*s*. 6*d*. net.

The recent reforms introduced into the methods of teaching geography in the Schools and Colleges necessitate the publication of text-books with a wider outlook on the different principles, and Messrs. Chapman & Hall have produced an excellent series of geographical treatises. We accord them a cordial welcome. The principal feature of these books is that at the end of every chapter, questions, exercises and problems are proposed, which vary in difficulty and in subject-matter, some being physiographic, some economic or historical and many anthropogeographic. The main advantage of such graded exercises is that the teacher and the students have a wide range of choice suited to their ability and interests. Most of the problems are applicable to countries other than those treated in the text-books. The knowledge of the local region, to which the problems are in the first instance to be applied, will furnish the background against the understanding of the remotest parts of the world, will become increasingly clear. The exhaustive list of reference works given in the book will be an inducement both to the teacher and the students to obtain additional information in working out the exercises such as are intended to be solved by the co-operative effort of a group of pupils and the teacher.

The province of human geography is very wide. It includes a description of the appearance, dress, manners, food, pastimes, occupations, dwellings, economic and social organisations, public institutions, government, religion, education and cultural history of the people of the world. They differ widely. It must be an interesting study to discover the causes which have produced wide differences in the civilisation, efficiency and progressiveness of the people. Every one of these problems suggests numerous subsidiary subjects for study and investigation.

The first part of the book dealing with man's relation to physical environment gives an idea of the scope of the enquiry attempted by the authors and is intended to serve as a general introduction to the succeeding parts. As an illustration of the problem in Human Geography the Khirghiz nomads of Central Asia are described in the preliminary section, which is a typical case of "segregation" or "isolation" of a small body of people who have reached a stage of exhaustion of adaptive potentialities and unless they come in contact with the more civilised nations, are bound to become extinct amidst their inhospitable surroundings. The history of these semi-civilised people is an excellent chapter in biology. Whether the influence of the environment is favourable or prejudicial to the growth of new civilisations in isolated territories, must depend both upon the community settling on them and on the natural

resources and assets of the lands. To the Papuans the message of the Niagara Falls must always remain subconscious; the genius of the Scotchman cannot transform the Kalahari desert into an earthly paradise. The efficiency of man in conjunction with good geographical surroundings determines his progress. The decline and extinction of the great historical civilisations are due to the causes which led to the disappearance of the races of gigantic creatures which at one time dominated the earth's surface. Just as the wheels of the railway coaches are tested at important stations, as to their soundness for undertaking the forward journey, so the civilised nations have to pause at important stages of their industrial progress, to test their adaptive potentialities in case of a sudden crash in their artificial environment.

The subject-matter of the book is wide and varied. It is adapted for the use of junior students as well as for the more exacting requirements of senior scholars. Interesting and important problems are prescribed for additional work. Students of Biology and Anthropology will undoubtedly profit by a perusal of the book. No person can follow intelligently the topical events discussed in the daily newspapers, if geographical knowledge does not form part of his mental equipment. Geographical works of this kind must have a great humanising influence, their message extends beyond instructing the intellect.

TERTIARY FAUNAS: A TEXT-BOOK FOR OILFIELD PALÆONTOLOGISTS AND STUDENTS OF GEOLOGY, VOL. II. THE SEQUENCE OF TERTIARY FAUNAS. By A. Morley Davies. (Messrs. Thomas Murby & Co., 1 Fleet Lane, E.C. 4, London, 1934, pp. vi+235.) Price 15*s*. net.

This book is the outcome of the needs of the students of Oil Technology of the Royal School of Mines for whom the author was required to organise a special course in Palæontology, and it deals with the succession of the Tertiary Faunas in all parts of the world. It is well known that the oil supply of the world is derived from the tertiary formations and a complete knowledge of these rocks and their fossil contents must be an indispensable part of the equipment of the Oilfield Geologist. However, the usefulness of the book is not restricted to oil-prospectors. To the geologists and all students of Palæontology, the book is equally important.

The author's intention was to publish his work on Tertiary faunas in two volumes. The first volume was to deal with the systematic portion of the subject, providing descriptions of all groups forming the assemblage of fossils peculiar to this epoch. The publication of volume I is delayed and the publishers hope to issue it towards the end of the year.

The author in his work on "An Introduction to Palæontology" introduces the students who have to study the subject as a self-contained unit, to the general facts, problems and results of this branch of science. The type-study system followed by this book gives the reader a full account of the common species from which he proceeds to obtain a general idea of the characters and range of variation of the group to which the particular species belongs. A knowledge of the outline of the subject is a necessary condition precedent for the study of Prof. Davies' work on the Sequence of Tertiary Faunas.

Palæontology is generally considered by students duller than even Mathematics. Evoking interest in either of these subjects lies in the mode of handling and presenting its contents. Palæontology in its general aspects dealing with the distribution and migration of animal groups, the conditions under which they flourished or became extinct, the significance of them in relation to the process of evolution and the correlation of geological formations in different regions and the former distribution of land and sea, provides us with a picture of the world that has passed away.

In Europe the upper reaches of the Cretaceous rocks are separated from the Eocene formation by an abrupt gap. The faunas of the latter are strikingly different from the groups occurring in the earlier deposits and the abrupt change is noticeable in the almost complete disappearance of the genera and species characteristic of the Cretaceous period. In India the Tertiary era is not only of interest in respect of the successive faunas, but also in regard to the physical history of the entire sub-continent including the Himalayas. It is usually held that towards the close of the Cretaceous, a large part of the Indian peninsula witnessed a series of eruptions, spreading lava and pyroclastic materials over an area of 200,000 square miles having a maximum thickness

of 10,000 feet. From a study of the petrological and mineral characters of these rocks known as the Deccan Traps which overlie the Bagh beds and Lameta series, their age is regarded as not older than the Cenomanian stage of the Upper Cretaceous, and not much younger than the Danian stage of the topmost Cretaceous. But recently the evidence afforded by the Fossils, tends to show that the Deccan Traps cannot be older than Eocene and it is presumed that they owe their origin to the great earth movements which overtook India at the beginning of the Eocene period which resulted in the breaking up and submergence of the Gondwana continent and the uplift of the sea deposits into the Himalayas.

The book under review devotes very little space to the history of the Tertiary Fauna of India and is almost exclusively occupied with that of the continent of Europe with such references to other land areas as may be necessary to give the students a conspectus of this most interesting epoch of the earth's history. No episode in that history is more dramatic than the rapid evolution in India of a most varied population of the different orders of mammals between the Mid-Miocene and Pliocene, usually known as the Siwalik system. On page 201 of the book, the term "Siwalik Hills" is just mentioned in connection with the Hipparian fauna of the Potian.

As a text-book for oil-field palæontologists, the book serves its purpose admirably and even students of general geology will find it a useful guide in their studies of detailed Palæontology. Within the limits prescribed by the author and the circle of students whom his work is intended to benefit, the book is certainly useful. It will be a welcome addition to general palæontological literature.

Students requiring more detailed information on subjects treated in the book and what is not fully treated, are provided with a complete list of reference works. The usefulness of the book is further enhanced by tables of approximate correlation of the Lower and Upper Tertiary formations and the principal mammalian faunas of Older and Newer Tertiaries. The mass of information contained in the book is its chief value.

PRINCIPLES OF ANIMAL BIOLOGY. By A. Franklin Shull with the collaboration of George R. Larue and Alexander G. Ruthven. (McGraw Hill Book Company, Inc., New York and London, 1934, pp. xiv+400.) Price 21*s*. net.

The fourth edition of Professor A. F. Shull's book is the outcome of the rapid changes taking place within recent years both in the content and the methods of exposition of Zoology. The subject has acquired a distinct human bias; experimental methods of research are increasingly adopted, and the study of behaviour has assumed a great importance. The changes in the method of approach to the zoological problems are more pronounced in America than in Europe. We have a great body of observational and theoretical facts in the new departments of knowledge such as ecology, genetics, and cytology of which there is an adequate treatment in the book.

The first chapter gives an account of the growth of biological science from the days of the early Greek philosophers, and traces the converging lines of the contributions which have rendered biology seemingly a composite science. The constituent parts overlap and thus give a unitary outlook to the subject. Their methods of study may differ; but all investigations ultimately tend to an elucidation of the phenomena of life and its evolutionary potentialities. A sketch of the life of the great biologists provides the necessary historical and philosophical background so necessary for the cultural value of scientific training. In the third chapter the student is introduced to the study of the elementary chemistry in its relation to Biology and this equipment of knowledge in a sister science is indispensable to an understanding of the operations of the cells. Then we have a series of chapters dealing with the organisation of cells and their constitution in the metazoa, their histology, physiology and reproduction. The chapter on genetics is accompanied by a number of interesting problems, and in the chapter on taxonomy, the requirements of a genetic classification and biogenetic law are briefly discussed. Chapter XVII is devoted to the exposition of ecological problems and the appendix to this chapter gives a synopsis of communities adopted by a Committee of the Ecological Society of America. The succeeding chapters on geographical distribution, fossil animals, modification of species are treated with reference to recent developments in each of these subjects.

The book supplies a distinct want. It is a valuable text-book. No pains have

been spared by the authors in carefully planning the subject-matter and presenting it in an easy and attractive manner. Of the many good features of the book, special mention is to be made of the profuse illustrations, the problems and exercises for further study, a list of reference books, and an explanatory glossary of technical terms. The comprehensive and lucid presentation of the whole subject-matter must be the chief recommendation of the book which we hope will be used in all the Colleges where biology forms part of the University course of studies.

THE DINOSAURS: A SHORT HISTORY OF A GREAT GROUP OF EXTINCT REPTILES. By W. Swinton. (Thomas Murby & Co., 1 Fleet Lane, E. C. 4, London. 1934, pp. xi+724.)

Generally speaking the history of reptiles is interesting as furnishing evidence of the reptilian ancestry of the higher forms such as the birds and mammals; and that of the Dinosaurs is fascinating as giving us an insight into the enormous size and complexity of these forms which at one time dominated the earth's surface. These terrible animals attained apparently a point of development at which they must have lost elasticity and power of adaptation to the new conditions introduced by the Tertiary era, with the consequence that their entire race became extinct. However, during the period of their maximum development, they had differentiated in a number of ways for the diverse modes of existence and the climatic conditions under which they lived.

The Mesozoic epoch, also known as the Age of Reptiles on account of the preponderance of these animals, witnessed the coming into existence of a bewildering variety of these creatures which dominated every sphere of life. Among the land reptiles of that age those which had adopted a mode of life suitable for existence on trees, in swamps, fertile plains and sandy tracts, are generally included in the group known as dinosaurs. The group is divided into two main orders on the basis of the elements comprising the hip girdle; the *saurischia* including the carnivorous and herbivorous forms and *ornithischia* comprising only plant-eaters. They lived within the period which commencing with the middle Trias ended with the Upper Cretaceous and consequently the diphyletic origin of Dinosaurs is postulated. Among the primitive ancestors from which other reptiles, contemporaneous with Dinosaurs, Ornithischia, Saurischia, pterodactyles, crocodiles and birds seem to have had their origin. The early members of dinosauria possessed a great evolutionary potentiality and this impetus of forward movement manifested in the appearance of the carnivorous (Theropoda), the amphibious (Sauropoda) and the beaked and the armoured forms (Orthopoda). The physical and biological characters of the world in which these reptiles moved and had their being, were far different from the distribution of land and water and the fauna to-day, and these conditions provided them with sufficient supply of food and suitable climate. With the disappearance of these reptiles, the aspect and the contents of the world have changed and have tended to assume the present day characteristics.

The book gives an excellent and complete picture of the origin, the anatomy and the general habits of these extinct Reptiles which both the amateur naturalist and the expert palæontologist will find interesting. It is a valuable addition to our palæontological literature. It is difficult to write a book on what is usually considered as an uninteresting branch of knowledge, which will be read with pleasure and profit and the author deserves congratulations on successfully accomplishing a task seemingly impossible. The illustrations are beautiful and the text figures are clear and helpful in understanding the anatomical features of the animals which form the subject of an indispensable course of palæontological studies. At the end of each chapter is given a complete list of references. In Appendix A is given a list of British dinosaurs only, but as the book attempts to deal with the group as a whole, one might wish for a fuller list of dinosaurs in the schematic form in which the British forms are represented. In Appendix B we have an explanatory glossary of all the scientific and technical terms used in the text, and this must be of invaluable help to all readers who are not familiar with scientific terms. The study of these animals is rendered complete by the inclusion of a chapter on the diseases from which they suffered, the causes which lead to the disappearance of the entire group, their homes, haunts and habits and the zoological and geological importance of their study. The dinosaurs have a message even to the mining and civil engineers whose interests have not been forgotten by the author.

We have read this book with genuine interest and profit and we have every reason to hope that other readers will find both in its perusal. This is one of those scientific works which every man who claims to be cultured must possess and peruse.

THE ECOLOGY OF ANIMALS. By Charles Elton. (Methuen & Co., Ltd., 36, Essex Street, W. C. London. 1933, pp. 87.) Price 3*s.* 6*d.* net.

The Oxford School of Ecology has popularised the subject and its influence is great. Sooner or later it is bound to form part of the systematic course of biology and together with the study of the behaviour of organisms, the two branches of knowledge, it is hoped, will impart a new outlook and significance to the teaching of general Zoology. The ecological study refers to the relation of the organisms to the environment, the inter-relations of animals, their population, general habits, migration, food and enemies and there are three methods of approach, *viz.*, field observation, experimentation, and nomenclature. The points of contact which ecology makes with other subjects are taxonomy, morphology and comparative anatomy. The study of animal behaviour, on the other hand, leads to comparative psychology and the action of physical limiting factors requiring a knowledge of physiology.

The British and American Ecological Societies have organised surveys and have defined communities. They were primarily undertaken in connection with agricultural research. The importance of plant and animal organisms in relation to soil fertility is a matter of common knowledge which has been greatly systematised and enlarged by ecological researches. From the point of view of developing marine forest and other resources, comprehensive ecological surveys have still to be organised and there are gaps in our knowledge of the number and variety of animals in grass moors, hedgerows, swamps, sand-dunes, ponds and hill streams, still to be bridged. There are other economic problems which fall within the province of ecological investigations, such as the diseases of man; those relating to useful land produce, fisheries including whale fisheries; conservation of useful mammals and birds. Apart from the interest which such studies have on the general health and well-being of man and the expansion and prosperity of his industrial organisations, the future of ecology as the accurate study of natural history is bound up with the planning of educational courses for rural and urban schools.

This little manual provides the reader with a general knowledge of the scope of this interesting branch of natural history in all its aspects. The book is a good addition to biological literature and students in schools and colleges studying biology will find it an excellent manual. Its usefulness to the practical agriculturists, to students of medicine and forestry is equally great. There is a selected list of reference works to which readers wishing for more detailed information than is provided in the book itself, may refer. The book maintains the high traditions of the Methuen Biological Series.

NATURE STUDY READERS: TEACHERS' SCHEME BOOK FOR FIRST AND SECOND YEAR PUPILS. By Phyllis S. Darling, M.R.S.T., F.R.G.S. (Oxford University Press, Bombay, Calcutta and Madras, 1934, pp. 55.) Price As. 8.

And

NATURE STUDY READER FOR SECOND YEAR PUPILS. By Phyllis S. Darling, M.R.S.T., F.R.G.S., with Decorations by Mina Buchanan. (Oxford University Press, Bombay, Calcutta and Madras, 1934, pp. 11.) Price As. 4.

These two little books do a great credit to the enthusiasm and sincerity of the author.

"The aim of this series is to help pupils and teachers, too, to collect evidence by being always watchful and ready to seize every opportunity that comes to them, then to try and draw conclusions by examining and classifying the material they have collected, and finally to test their own conclusions, by comparison with those of others and by further investigation."

Stated in a less eloquent way, the object of the book is to open the eyes of the pupils to the variety and beauty of animal and plant life in their surroundings so as to lead them to take an intelligent interest in the habits and interrelations and life histories of animals easy to be kept under prolonged observation. Children take a great interest in making collections, in sorting them out and naming them. This instinct is the basis of all future education, the success of which depends upon its early cultivation.

In the Indian schools, there is a dull uniformity of courses and the little interest and curiosity which the children may bring with them are practically killed either by the ignorance of the teacher or by the stupid

curriculum. If the educationist were to succeed in introducing nature study as part of instruction, it is forthwith taught from a book in schools situated in the busiest streets of a populous town. Education in Indian primary schools is deplorable. How the children survive this torment, is a mystery. A large number succumb annually. Education yields its best results when it is imbibed unconsciously. Have we provided for it? These little books point to the way how to do it.

The lessons for the first and second year are carefully chosen and the pupils are given plenty of interesting exercises which they would love to do. These books are intended to provide guidance to the teacher and the author has been careful not to give details lest they should be dictated to the pupils. If the instructions of the book are faithfully carried out, we have no doubt that the children's powers of observation, their manipulative skill and desire to learn first hand are bound to improve.

We congratulate the author on the extreme care and sympathy with which she has written the books for the use of the little pupils who, we have no doubt, will greatly profit if the teachers in charge of them know enough of the subject-matter to handle it intelligently. We would like to see further publications of the series for the higher classes.

THE ELECTRONIC THEORY OF CHEMISTRY. By R. F. Hunter. (Edward Arnold & Co.) Price 8*s*. 6*d*.

The Electronic Theory of Valency, a logical development of thought and experiment in the field of theoretical and experimental physics and chemistry, has now advanced to such a stage that no serious student can afford to neglect its study. The synthesis of urea is considered to be the birth of synthetic organic chemistry, and in a sense the conversion of ammonium cyanate into urea is a tautomeric change. In spite of the fact that tautomerism was known for over a hundred years and many examples are crowded in all books dealing with organic chemistry, no intelligent explanation of the phenomenon was possible till the Electronic Conception of Valency was applied to organic reactions by the British School of Chemists.

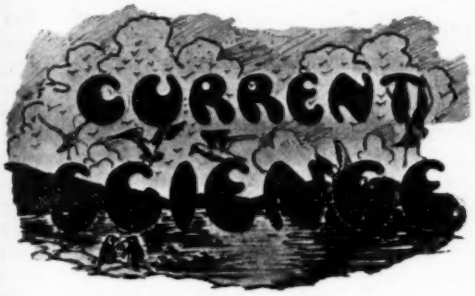
The theory of aromatic substitution has been a difficult side of organic chemistry till Lapworth, Robinson, Ingold and their collaborators placed it on the sure footing of electronic conception. The conception of the sextapule (closed group) theory of benzene constitution, developed by Robinson and Ingold, and applied by Robinson to explain the "aromatic type", has been the subject of a brilliant analysis by Hükel. The classification of reagents into different groups by Lapworth and Robinson, and Robinson's experimental substantiation of a series of organic reactions have effectively settled many vague and profitless speculations.

The stability of free hydrocarbon radicals was first tackled by Ingold who introduced the conception of ionic dissociation of hexaphenylethane molecule. Recently Pauling and Wheland have applied the quantum mechanical method of calculation of resonance energy to free hydrocarbon radicals, and their results lend great support to Ingold's theory.

Sidgwick's theory of co-ordination is one of the greatest achievements of modern inorganic chemistry. The explanation of the ammonium-ion formation by the co-ordination of a proton is the only intelligent explanation available. The structure of the isocyanide group and carbon monoxide on the basis of semipolar double bond have received considerable support from the study of Raman spectra. The work of Heisenberg, Dirac and others have resulted in the conception of the single electron linkage, and its applicability for elucidating the structure of many compounds has been fully demonstrated.

The book under review is a very admirable treatise of the subject and is certainly an acquisition to chemical literature. It is conveniently divided into twelve chapters and these, taken either individually or collectively, are difficult to be improved upon, considering they are the subject-matter of a series of lectures, normally of an hour's duration. A highly satisfactory author index and subject index, and the important references given at the end of each chapter add to the usefulness of the publication. I would, without the least hesitation, recommend to each and every student of chemistry to possess a copy of Prof. Hunter's contribution to the study of modern organic and inorganic chemistry.

K. N. MENON.



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Presidential Address.

By J. H. Hutton, C.I.E., M.A., D.Sc., F.A.S.B., I.C.S.

[The preliminary portion of the address is devoted to a recital of the history of the Academy movement which led to the formation of the Committee by the Indian Science Congress and the subsequent developments, ending in an exhortation to the Congress members to accept the report of the Committee for the formation of the National Institute of Sciences of India. Dr. Hutton then proceeds to give an account of the social and anthropological problems arising from the Census Report of India for 1931.]

I NEVER realised, nor came near to realisation of the vast field that there is in India for the organised efforts of science until the Census of 1931 put me into a position in which I could hardly overlook it. The first essentials of sociology are accurate statistics, and most of the few statistics available in India are obtained by crude methods and give results which are insufficiently exact. We know for instance that the population has increased but we can only guess at the causes; we cannot in India as a whole be certain of where or when the increase took place beyond locating it over a period of 10 years. In Madras alone was the registration of births and deaths sufficiently accurate for the population of 1931 to be determined approximately before the counting took place, and even then we cannot be sure that that accuracy was not an accident. How far the variation of fecundity in different parts of India is due to environment, heredity or social customs we have no means of knowing, since detailed local studies are wanting. Mr. Porter in Bengal has embodied in his Census Report for that province an interesting speculation on the future growth of the population of Bengal; but the figures on which it is based being limited to seven enumerations are not enough to warrant our taking it as more than a speculation. Even so it leads us at once to the urgent need of a greater application of science to matters of rural economy. It is probably true enough that improved methods of agriculture can so increase production that the population of this country is not an immediate danger of outstripping its potential food supply. But I say potential advisedly. It is very clear that in other respects the position is serious. The vast majority of India's population live an agricultural life

not only by force of circumstances but by deliberate preference and under their existing conditions of ignorance and of absence of capital, the population attempting to live by agriculture is likely to become, if it has not already done so, much too numerous for the land to support. The subdivision of holdings which are insufficient to maintain their owners, must tend to reduce the economic output from their land while the increase of cultivators and in particular of landless agricultural labourers calls for an increasingly high return from the land. In limited areas and to a limited extent some relief is afforded by seasonal industries (such as cotton in Central India) which enable the agricultural population to add to the income derived from land; in other areas cottage industries give similar assistance, but the extent of these reliefs is entirely inadequate to the need, and there is an obvious call for a great extension of part-time industries in which the cultivator can find employment when he is not required on his fields. To give one instance, it is probable, if not certain, that the application of scientific methods of breeding, feeding and selection could double the outturn of silk in India without any increase in the number of cocoons, and could at the same time enormously improve the quality of the silk. Indeed, for at least one Assam tribe the silkworm provides not only clothing but an article of food, as the pupa is much relished and reserved as a delicacy for favoured guests. But without seeking to popularise this use of the silkworm, the extension of silk producing, on scientifically improved methods, as a cottage industry might make India easily the premier silk-producing country in the world.

Further, although at present there may actually be enough food in quantity to prevent the great majority of cultivators from going hungry, it is becoming increasingly apparent that their diet is very often extremely badly arranged. A very great deal of the disease in India is deficiency disease due more to a badly chosen diet than to actual scarcity of foodstuffs. This point is well brought out, for instance, in Mr. Yeatts' Census Report on Madras where he emphasises the researches of Sir R. McCarrison on the causes of blindness in India indicating that the widespread prevalence of keratomalachia is due to a diet deficient in fat-soluble vitamins. It is likely also that leprosy, to take another instance, is encouraged by deficiency diets. Sir John Megaw again, in his paper on *Population and Health in India*, tells us that in India, although three meals daily is more common than two, 'malnutrition due to unsuitable diet is the rule rather than the exception'. Here then is one practical task for doctors and health officers: that of prescribing a suitable diet within the means of the very poor conformable to the local products available in the neighbourhood. An example of what can be done in this way may be seen in Mr. Mukerjea's Report on the Census of Baroda, 1931, where Dr. F. P. Antia and Mr. F. S. Kale give a food survey of the principal castes in the State. I would at this point put in a word of warning against those enthusiasts for reform and improvement whose zeal is greater than their knowledge. It is perhaps partly because the results of intemperance are so obvious and easily appreciated that the advocates of temperance are apt to be fanatic extremists, though I have known some who tempted one at times to recall Samuel Butler's caustic comment on the Puritans who 'compound for sins they are inclined to by damning those they have no mind to'. My point is that home brewed beers form a very important element in the diet of the more primitive tribes and castes of this country. Not only does the very moderate amount of alcohol in these brews supply for certain purposes the want of sugar which in many of their environments they cannot obtain, but the recent researches of Col. Chopra on vitamins have shown that the home brewed beers of India contain many very valuable vitamins, and there is consequently a serious danger that propaganda or legislation directed to the suppression of the use of these liquids may result in the spread of deficiency diseases, and add one more tally to the lamentable tale of damage done by well-meaning but ill-informed tampering with customs that are disapproved by the reformer but are in fact useful adaptations to environment on the part of the ones to be reformed.

Unfortunately, however, it is not only rural economy which calls for the aid of the scientists, though the rural call is the more urgent, not only because there are more than eight countrymen for every single townsman in India, but because the rural population is infinitely the more conservative and therefore in much greater need of that 'new outlook on life', the necessity of

which is admirably emphasised by Sir John Megaw, in the paper which I have already cited, with a telling quotation from the concluding chapter of the Report of the Royal Commission on Agriculture. Such a new outlook is easier for the townsman to acquire, for in exchanging a rural for an urban life he comes into daily contact with new ideas and new ways of living. Unfortunately, these ways of living are in some respects no improvement on the old. The Indian village, at any rate in northern, western, central and parts of southern India, often on a constricted site which cannot be expanded on account of the need of land for agriculture, is apt to be congested to a highly insanitary degree: but in towns this condition is often incredibly accentuated, and while 26% of Bombay's 1,161,380 inhabitants live under conditions of the grossest overcrowding, 74% of that population live in one-roomed tenements at more than 4 persons per room. Buildings of one storey predominate in Indian towns, which makes the figures of congestion, when the population for a given area is compared with congested population in Great Britain, appear lower than they really are, but where, as in Cawnpore, tenement buildings are used, the congestion is almost incredible. One chak of the Anwarganj ward of Cawnpore contains a density of 786,560 persons to the square mile, a figure untouched by the worst of the metropolitan boroughs of London. Obviously there is a need for scientific planning in the outlay and growth of all developing urban areas if a repetition of this sort of scandal is to be avoided. It was a matter of considerable surprise to me to find that in many parts of India the existence of a town with a large and concentrated population was regarded as an occasion for pride and complacency. A large town appears much rather to me as a source of fear and repulsion. It is true that the works of such men as Sir Raymond Unwin have shown that there is no need for this, but nevertheless such parts of India as Assam, Malabar and Eastern Bengal, where any close concentration of population is the exception, appear to be the more fortunate for that, and India has a wonderful opportunity of profiting by the experience of Britain and avoiding, by careful and scientific planning while her industries are still in their infancy, any further concentration of industrial population in congested areas.

I have referred to these points of rural economy of diet and of town planning merely as instances of matters in which science may and should be utilised and directed for the benefit of the community; there must be many more which will no doubt be discussed by the various sections of this Congress, much more fruitfully than by me. There are, however, certain aspects of my own special subject to which I propose now to direct your attention. India offers a vast field to anthropologists and opportunities such as exist nowhere else in the world, forming as she does a veritable museum of living physical types, of social organisations, cultures and religious beliefs. From the point of view of physical anthropology there is a vast amount of work to be done. India contains in forms that are anatomically distinguishable elements derived direct from the negrito races which constitute probably the oldest type of human being anywhere surviving. These elements are no doubt few and rare, limited to the Andamanese, rapidly alas becoming extinct, and to one or two of the remoter jungle tribes of the south of India. Similarly there are to be found survivals of that other eastern negroid race, the Melanesian. These survivals are more easily to be traced in culture than in anatomy, and it is not unlikely that the typical appearance of the Melanesian race itself is the result of hybridisation. Nevertheless evidence is to be found of affinity in physique between some of the Assam hill tribes and the races of Papua and New Guinea, and it is probable that such affinities occur again in some other parts of India. On the other hand, the physical type which Col. Sewell has conveniently labelled Proto-Australoid is widespread in India and Burma. This race possibly represents an early branch of the brown race of the south-east Mediterranean which migrated eastwards at a very early date and has been modified by environment to produce a markedly different type. On the other hand, it may be connected with some of the recent finds in Palestine, which Sir Arthur Keith appears to regard as related to surviving types of man. These views are not necessarily mutually exclusive. This race is represented most strongly in the lower castes and in some of the aboriginal tribes particularly of southern India. These races have been followed by others whose order of coming is more difficult to determine. One race of invaders, probably

likewise moving from north-west to south-east, must have brought in the Mon and Munda languages and possibly the keeping of sheep. Like their predecessors they seem to have formed definite connections overseas and to have moved on from India to Indonesia as the succeeding races did afterward. It was perhaps after their coming that the Parœean or Mongoloid races began to come down from the north-east, particularly in eastern India and Burma, but whether they ever penetrated far into India except at a much later date is doubtful. There is a suggestion of the Mongoloid about many tribes, in the Madras Agency Tracts, for instance, but it is not clear that this element did not come in from the east by sea together with the returning wave of speakers of Mon languages which certainly came back from the east westwards into Assam. In 1930 Mr. J. P. Mills and myself published in the *Journal of the A.S.B.* an account of some stone funerary urns found in the North Cachar Hills, which were then, as far as we could ascertain, unique. Since that date groups of very similar urns, used for an obviously identical purpose, have been discovered by Mdlle.Colani of the École Française d'Extrême-Orient in Tonkin in Indo-China, so that the Khasi-Synteng group in Assam can now be connected with the Far East culturally as well as linguistically.

And here is a point at which the geologists can help us. I have suggested elsewhere that a wave of immigration into India from east or south was caused by the subsidence of the mass of the Indian Archipelago. There are traditions among the hill tribes of Assam, Burma, Eastern India and the islands themselves which seem to me to point to a great volcanic cataclysm and a submergence of land under the sea which drove them to escape into the hills and ultimately to migrate; Messrs. Peake and Fleure, in that admirable series *The Corridors of Time*, have pointed out that if the coast line of the Indian Archipelago be extended to the hundred fathom line a great land mass appears which very nearly joins the Asiatic continent to Australia, and that some such reconstruction is necessary to account for the early occupation by man of the Australian continent; Molengraaff and Weber in their work on the Zoology of Indonesia have pointed out that the distribution of the species of freshwater fish in the islands suggests land continuity up to a comparatively recent date. The suggestion I made of the migration of certain tribes as the result of a volcanic upheaval and submergence met with quite definite disapproval at the hands of the geographers to whom I propounded it last year in London, but since then I notice that Corbett and Pendlebury in their work on the Butterflies of the Malay Peninsula have been led independently to a precisely similar conclusion to that reached by Molengraaff and Weber when working on the fish; I think I am justified therefore in stirring up the geologists to re-examine the possibility of the subsidence of Indonesia after its occupation by man, and at what is, geologically speaking, a recent date.

Whatever the provenance of the Mongoloid element in India, however, its physical influence appears to have been very small, and the main bulk of India's population would appear to be of Mediterranean origin, and it is possible to show much evidence for a continuity at a very ancient date of both race and culture from south-eastern Europe through Asia Minor, Syria, Mesopotamia and Iran to India. Into this population brachycephalic elements have entered probably coming both in the form of an admixture with the civilised Mediterranean and also in the form of a definite brachycephalic migration which has affected certain areas in India, of which Bengal is one, very much more strongly than others. It is possible that this latter brachycephalic element brought in the Pisacha or Dardic branch of the Aryan language, a purer form of which followed with the dolichocephalic Aryan invasion of about 1500 B.C. This difficult question I have discussed at greater length elsewhere, and I do not pretend to regard the position advanced as conclusively proved and established. What I do urge is that the question of race in India is one which calls for very careful and detailed examination by trained anthropologists on the lines recently adopted by Dr. Guha of the Zoological Survey and those workers who have been assisting him. The method of working by the coefficient of racial likeness is laborious and involves an amount of mathematical calculation which is more laborious even than the taking of the measurements, but results of permanent value cannot be obtained without the initial labour and this should be extended to all parts of India and to every tribe and caste.

It should also be supplemented by a corresponding analysis of the blood groups of such castes, since it is possible, if not probable, that these may give no less important indications of relationship than anthropometrical measurements. You have in India in the caste system a most valuable opening for approach which is denied to other countries where racial mixtures have gone on in a far more promiscuous way than they have in India. I do not suggest of course that caste is any necessary criterion of race. I feel certain that it is not, but it has divided up the population into endogamous groups which must have very greatly retarded and restricted the extent of miscegenation, and investigation is urgently called for before that system begins to break down under modern conditions. Meanwhile that same system affords opportunities for the study of human genetics not found elsewhere; it also opens up an approach to the study of the effects of environment on physique, since if castes which can be shown to have had a common origin and to have kept their strain pure but which are now domiciled in different parts of the peninsula are found to differ physically, the differences may be examined to see how far they can be traced to climatic or to other environmental causes.

In prehistoric archæology there are any number of sites awaiting excavation, and it seems highly probable from finds that have been made in Bihar that the Mohenjodaro civilisation extended not only to the Indus valley but to the valleys of the Jamuna and the Ganges as well. We do not yet know the meaning of the ideographs used by the people of the Mohenjodaro civilisation, nor what was the language used. It seems likely that it was a Dravidian tongue, but it might conceivably have been a Munda one. A mere reference to Munda is enough to remind one that our serious lack of knowledge of the distribution of this language shows how great is the necessity of linguistic research in southern India. Sir George Grierson's great work on the languages of India did not include the province of Madras, and we have no knowledge whatsoever of whether any trace of the Munda or Mon linguistic family exists south of the Godavari river or not. I suspect myself that such traces will be found in the uplands of Mysore, but that is a pure guess. An extension of the linguistic survey to the whole of south India is urgently needed; meanwhile we cannot tell whether the Munda speakers ever penetrated to the south or not, nor what traces, if any, survive of any of the languages that must have preceded Dravidian there. But we ought not to be content with mere linguistics. There is a branch of research in which so far as I know very little indeed has been done in India, but which if taken up comparatively is likely to lead to valuable results. I refer to the symbolism of dreams. Such work as has been done on this subject in Europe tends to show that the symbols of dreams are of universal application. Thus to dream of the loss of a tooth foretells the death of a relative in all parts of the world; most often, but not necessarily, it refers to a maternal relative, which is perhaps in itself significant. Now Freud makes a suggestion that the dream symbols used by the 'subconscious' to avoid the censorship of the 'ego' may be the survival of a symbolic language in use by the human race before any language, as we understand the word, developed. It seems not unlikely that when primeval man got beyond the stage of chattering, squealing, and grunting in different tones of voice, he communicated by means of a very limited vocabulary in which one word or symbol had to serve all sorts of different meanings connected only by some real or suppositious similarity in the objects named. The suggestion is an interesting one, and I would recommend a comparative research into the dream symbols of various castes and tribes as one which might throw some light on the pre-existence or otherwise of such a symbolic proto-language, and which would at any rate test the claim which has been made that dream symbols are of universal application. It has to be borne in mind of course that conventional interpretations of dream symbols may have been communicated, at a much later stage in human evolution, from one people to another in the manner in which folktales have spread all over the world, and that the diffusion or universality of conventional interpretations of dreams is not necessarily relevant to the hypothesis put forward by Freud, in which the symbol is used by the subconscious self in cases in which the ego disapproves and suppresses the use of a more easily recognised vehicle of expression

—Here the interpretation is not available until supplied by psychologists.

In the study of folk-lore proper only a beginning has been made in India, and a vast deal of material is disappearing very rapidly under the influence of missions and of the general change in the manner of living which is being brought about by the opening up of communications generally. Dr. Bake, a Hollander, has recently been working at Indian folk-music and has shown us what *can* be done by an enthusiast, while Bengal has set an example to other provinces in a revival of folk-dancing.

Turning to religion we find in India beliefs and practices which seem to have survived from a very early date in human history like flies preserved in lumps of Baltic amber. Thus traces are easily found, not only in tribal beliefs, in which the principle is sometimes specifically formulated, but in folk-religion as distinct from orthodox dogma, all over India of a belief that life is a finite and material substance. It is this belief in the transferability of life, so to speak, that underlies the practices of head-hunting and human sacrifice, though in the case of the latter the ideas of propitiation and expiation have doubtless entered later at a sophisticated stage when the original idea which gave rise to it had begun to fade. It also underlies many funeral practices in this country which are arranged with a view to the transference of the life-matter to the crops, whereby it is again consumed by human beings and used for the propagation of fresh individuals by the begetting of offspring. Elsewhere I have pointed out that the same idea appears to be the basis of the practice of temple prostitution. Now I suggest that this idea of life as a material substance arose very early in human prehistory. Primitive peoples to this day have great difficulty in expressing anything but a concrete idea; primitive languages are apt to contain no words for abstract ideas. Clearly the inference is that at a primitive stage of thought only concrete things can be conceived of, and the first man who reflected upon the difference between a dying body and a dead one conceived of that which had left the body as some material substance which had leaked out of it, which is very much how the Karen states the case at this day, while this view of the nature of life is not only common throughout India in tribal religions but may be traced in Hindu philosophy. The Vedanta conception of the soul with its successive sheaths is probably one instance, and a more concrete one is to be found in Manu's condemnation of the Teli and his relegation of him to an outcaste position on the ground that he is a destroyer of life by crushing the oilseed for the extraction of oil; hence the distinction in Bengal between the Teli who crushed the seed and are therefore outside the pale and the Tili who merely traded in it without having committed the sin of destroying life. Another instance of the way primeval things survive in India is perhaps to be found in the common prejudices in regard to red ochre. When arranging for the numbering of houses in the 1931 census I found that red ochre was a desirable pigment to recommend because almost all over India the use of red ochre is regarded as fortunate, and while people are likely to object to numbers tarred or painted on their houses, the affixing of numbers in red ochre was regarded as more lucky than unsightly. I do not know the cause of this and I do not know that anyone knows why this superstition attaches to red ochre, but it struck me at once that it might well be a survival of some belief that was obviously at work in the old stone age. It is clear from many prehistoric finds that Palæolithic man treated the bones of the dead with red ochre and the find at Offnet of a large number of heads so treated without the appropriate skeletons suggests that the use of ochre may have at one time been associated with the practice of head-hunting or with that of a separate disposal of the head in burial, a practice still popular in parts of the hills of Assam, where it was once more prevalent than it is now, in parts of Burma, of Indonesia and of Melanesia.

I have said enough to indicate I think the enormous field there is in India for anthropological research. What is most wanted at present is the organised collection of facts, of facts, that is, uncoloured by any preconceived ideas. Facts once collected and put on record can be interpreted at any time, while premature interpretation is too apt to predetermine the actual facts collected, and all the time precious material is disappearing at a rapidly increasing rate. The tremendous change which motor transport has introduced into India has only just begun to be felt, but the general improvement in means of communication is indicated by a rise in 1931 in the figures of every form of road transport except those of palki-

bearers, who show a not very remarkable decrease and a rise in the figures of persons employed in the construction of means of road transport, and a corresponding rise of over 300% in the figures of owners, managers and employees connected with mechanically driven vehicles. This change is having an incalculable effect on country districts and you must expect to find that an incredible quantity of traditional belief and custom will disappear in a generation. Change has been fast enough in Britain. I can remember as a child taking part in more than one Easter egg-rolling, and you may search very far before you can see one there now-a-days, and I can remember watching the performance of what must have been one of the very last bands of the old folk sword-dancers before the artificial revival of folk-dancing; but in this country I have seen whole villages entirely abandon their ancient customs in the course of a few years, and there are no written records by which the rising generation of such villages can have any knowledge at all of the practices of their own fathers. It is therefore to the collection of the existing material of folk tradition before it is lost that this generation of Indian ethnographers is called and I would further urge that intensive work on a limited area is far more valuable than extensive work which necessarily involves generalisation. That can always be done later. Local differences are often very great and the minor differences found from district to district may be of great significance. Different areas with different environments need different treatment, and it seems to me that we suffer much, too much already in India from too much centralisation, and too much generalisation in every form of activity.

The question is likely to be asked what, if any, is the practical value of a study of anthropology. I offer no categorical answer to that question, but I do offer a few instances in which its practical value is sufficiently obvious. Thus in Africa the substitution of Indirect Rule for the older system of direct administration is the immediate result of applied anthropology. Indirect Rule is an educative system and its objective is to evolve by a natural process an indigenous system of administration which shall conform to civilised standards without jettisoning what is good and environmentally suitable in the native systems which Direct Rule must completely obliterate. To quote the Report of the Kenya Land Commission:—"The principle is that it is better to take the native customs as they stand and build from them as a basis, than to rely upon some novel but imported pattern which would not be understood—." Such a principle involves of course not only the knowledge of what is but of what has been; the knowledge of the origin and *raison d'être* of customs and belief, since no complete understanding of these is possible without the knowledge of how and why they came into existence and developed as they did. The experiences of Africa have an important bearing on the administration of the more primitive parts of India, and it would probably be wise in our administration of tribal areas to look for light not from the east but from the dark continent. *Semper aliquid novi Africa adfert*, and although the system of Indirect Rule has lately incurred much criticism and may in some cases have been carried too far, we have had only too little of it in India. Anthropologists have been accused, incidentally by Mr. Jayaker, of wishing to create for their own edification living museums of people whose sophistication is retarded to their disadvantage. In point of fact this criticism is most unjust. What the anthropologist does seek to do is to apply his acquired knowledge and experience so to modify contacts between primitive and advanced cultures that the former may not be, as they so often have been, ruthlessly extirpated by the latter, a process invariably accompanied by the decimation, if not annihilation, of the races whose culture is destroyed.

At the same time the answer to any question as to the practical value of anthropology must obviously depend to some extent on the circumstances under which the question is asked, and in the case of this country I would suggest that, apart from any administrative question, anthropology may be able to provide a solution of certain problems of very great importance to the people of India. India shows a marked contrast to Europe in that the number of males exceeds the number of females; various explanations have been sought in differences of climate, differences of race, or differences of social custom, but no one has yet studied the subject so thoroughly as to be able to offer us any convincing explanation of the phenomenon.

Again, it is for the anthropologist to consider and determine not only its causes but what will be its results. It is both contended and disputed that in-breeding leads to an excess of masculinity. If that be true (and there are weighty opinions on that side) then the caste system is likely to be one factor in producing this excess of males. If so, will such an excess have a good result or a bad one? In the former case caste is clearly an institution to be cherished; in the latter case we ought to do all in our power to encourage intercaste marriage. Here is a problem for the examination of anthropologists, a research problem of very great practical importance. It is not so much for the anthropologist to say whether or not an excess of males is a bad thing, as to determine the causes and consequences of such an excess; to say whether the observance of caste is a factor therein and whether intercaste marriages tend to produce a more even balance of sexes. An enquiry of this kind should not be an impossible matter in a town like Calcutta. Sir John Megaw, in a much discussed paper read last February before the East India Society, emphasised 'the urgent need for the people of India to adopt a new outlook on life'. Such a new outlook can, I claim, be supplied by anthropology, which should teach us to 'see life steadily and see it whole'. Life is very largely governed by custom and prejudice, and often so rigidly that these factors amount to tabus, for tabu in its broader sense is no foible confined to savages but an attitude of mind which they share with the most civilised, and which is common to all religions which depend on any hierarchical organisation or any schematic creed. Untouchability as observed in India is a precise instance of tabu. Tabus when they arise, may be admirable and even necessary, but like all religious dogmas tend to survive long after the necessity has declined and their moral justification has vanished, a survival which is often to the moral, social, or economic detriment of the community which holds them. Many instances of this might be given but it will be enough here to mention a tabu on the planting of rice in certain Naga villages. Where agricultural operations are carried out very largely by the work of the community acting together, it is obviously necessary to control the inception of successive stages, and to maintain their control a tabu is laid upon sowing and upon transplanting before the controlling official gives the word by an inaugural ceremony. Otherwise there would be a tendency for those whose fields had completed one stage with the help of their neighbours to go on to the next instead of helping the rest of the community to achieve a similar completion first. The successive operations of the agricultural year are therefore all governed by a series of ceremonies and tabus, the inauguration of which has been fixed at the time which experience has shown to be most suitable in the environment. So strong has the respect for these inaugural tabus become, that people migrating from one area to another have frequently continued to refer to the village of their origin for the dates of the ceremonies to be performed in their new village, and have thus perpetuated an agricultural calendar which is not suited to the changed environment, and although they themselves recognise that at their new and, for instance, lower and warmer altitude an earlier sowing or transplanting would be advantageous, they prefer from religious or superstitious reasons to retain the dates suited to the village of their origin and to suffer considerable economic damage as a result. Similarly the system of *tabu* was probably essential to the authority and position of the Maori chiefs, but so strong was the prohibition on touching one that a case is on record of a chief who was rescued by a missionary on the point of suffocation from a fish-bone stuck in his throat which none of his people could remove on account of that tabu.

Now the reason why tabu, useful in origin, is carried to an extreme which is merely damaging is that it has a definitely religious sanction, and all religious sanctions tend to be not only dogmatic but extremely rigid. This rigidity is no doubt a quality necessary to their enforcement to the first instance and to their survival of their initial inconveniences. At the same time its ultimate effect is to take such injunctions as, for instance, 'what God has joined let no man put asunder' and 'thou shalt not commit adultery', and interpret them so stringently as to make them prohibitive of divorce or of the remarriage of widows under any circumstances at all, giving us a stone for bread.

Professor Haldane has recently drawn attention to the fact that human morality is usually relative. He refers to that father

of modern science Aristotle, who, he says, 'saw clearly enough that right and wrong are usually quantitative. Thus according to the amount of risk taken in a given situation, conduct is judged to be cowardly cautious, brave or rash. There is an optimum somewhere between two extremes just as there is an optimum temperature for a growing plant.' He goes on to point out that the principle is 'perfectly familiar in science, as when a substance exhibits new properties with rising temperature, or an aggregate of many similar molecules displays characters not found in a single one.' The conclusion he draws is that a human code of ethics must be plastic and capable of adjustment to changes in the economic structure of society, and a code which is rigid is a dangerous anachronism. It is, however, the tendency of all hierarchical codes to aim at rigidity regardless of environment. It is just that spirit which, to use two more of Professor Haldane's illustrations, induced British bishops in the early 19th century to vote in the House of Lords against a bill to abolish the penalty of death for stealing by children under 16, and in this 20th century to oppose the legitimisation, by the subsequent marriage of their parents, of children born out of wedlock. It is the same spirit which is abroad in India opposing changes in the marriage laws or the entry of exterior castes into temples. Because a mediæval widow must burn with her husband or live celibate till her death, her remarriage is still discountenanced; because a thousand years ago it was considered advisable to marry off a daughter before she reached puberty therefore it is a sin not to do so to-day. There is ample evidence that the relative proportions of the sexes at certain ages differ in India from those in Britain largely on account of the great mortality among girls who are married and caused to bear children before they are physically fit for it. Yet the Sarda Act is a dead letter and the interval between its passage and its taking effect was used to perpetrate an enormous increase in infant marriages, not only among Hindus but also among Muslims and Christians. A careful investigation into the causes of death in childbirth in Madras showed that in 6% of *all* confinements the mother was under the age of 15, and if any one needs light on the excessive mortality among Indian girls aged between 15 and 30 he has only to turn to the Report of the Age of Consent Committee and the horrid volumes of evidence attached. Clearly there is need for the new outlook referred to by Sir John Megaw, particularly in the more rural parts of India.

Another end which I believe that anthropology can further, is that of a better understanding between nations and races. Nor do I refer merely to the very obvious need of a mutual understanding between Britons and Indians. Misunderstandings exist no less between different racial and social elements within India and are in just as much need of liquidation. It is a commonplace that to know all is to understand all, and clearly a knowledge of the characteristics and genius of an alien race as determined by their composition, their history and their environment is likely to make it easier to allow for points of difference and to appreciate by standards that are other than our own. The increasing ease and rapidity of communication is causing the world to shrink with a speed which is very disconcerting, and unless we can learn to put up with, as neighbours, peoples and nations that were merely names to the bulk of our forefathers we shall find it an uncomfortable place to live in. Change is proceeding at a pace that rapidly increases as it goes along, *vires acquirit eundo*, and although in India it has been extraordinary slow in the past, it is already very much faster and may become extremely fast in the near future. The geographer Ptolemy writing nearly two thousand years ago referred to the Nagas and placed them on his maps approximately where they are to-day, but though the name remains, he would no longer recognise their country as the realm of the naked, though this change has been taking place only in the last few years, and may not yet be regarded as complete. But nearly everywhere in rural India the last 20 years has witnessed a tremendous change in the standard of living and a very rapid introduction of new ideas and new practices. *Tempora mutantur et nos mutamur in illis*, 'times change, and we to fit them', may still be true, but for a great many of us the change is becoming too rapid to be at all comfortable, and there is real danger that the more backward may be entirely destroyed by failure to adapt themselves to the changed environment. What the anthropologist seeks to do is to control their contacts with a more sophisticated civilisation in order that they may have a reasonable chance of

adapting themselves to a changed environment and escape that complete destruction by disease and vice that contact with civilisation has brought to so many people of comparatively primitive economic culture. The object is not to chain the individual to his existing environment, but by giving him the opportunity to adapt himself to changes at his own rate to enable him to control his environment by the development of his own culture. The attempt to 'civilise' has generally meant an attempt to make in a hurry a perfectly good savage into an unsatisfactory or useless imitation of an inferior Bengali or an inferior European, unsuited to the surroundings in which he finds himself and able only to subsist as a parasite on society if he can be found what Nagas describe as a 'sitting-eating job'. It is against this process in any of its many forms that anthropologists seek to take precautions, and it may be claimed that at least in Africa they have effected something, and I am one of those who think that it is still not too late in parts of India and Burma, and that we can do no greater harm to people who have a culture of their own already adapted to their environment, than to filch it from them, before they have any means of appraising comparative values, by the substitution of another, unsuited to the environment and disguised under the insidious pretext of "uplift", which so often merely substitutes new tabus for old, while leaving the attitude of mind, the outlook on life completely untouched. The only case I know of in which the mere museum-of-exhibits policy could be justified is that of the Andamanese, who are probably so far removed from the conditions of modern life and from any qualifications for sharing it, that it is to be doubted whether adaptation is at all possible, without completing the destruction of what is left of them in the process. Fifty years of contact with the penal settlement in Port Blair has already reduced their numbers from over three thousand to a mere 450. A strict isolation is probably their only chance of survival, and they really ought to be preserved from extinction if only as scientific specimens of a type of human being elsewhere long vanished from the face of the earth.

Finally, anthropology like any other science is worth pursuit for the sake of knowledge alone. Great advances have been made in those sciences which give us knowledge of our environment. Geologists can tell us the composition and history of the earth and astronomers penetrate yearly further into space. Great advances have likewise been made in the sciences such as chemistry and physics which give us control over material substances and physical forces —but the merest beginning has been made in those sciences which give us knowledge of ourselves, a knowledge without which we can never hope to control the destiny of our race. The science of anthropology is the first step towards the acquisition of such knowledge. It has taken man about a million years to reach his present state of existence, and Sir James Jeans estimates that the earth will remain habitable for a million times that period again. What the human race will be like if it survive to such an æon, is clearly beyond the imagination of man, but one thing may be taken as certain and, that is, that will need all the knowledge it can have of its past and its present, of its nature and composition, and of the controls, if there be any, of its own development, if it is to succeed in adapting itself to the changes inevitable in so great a period of time. It is impossible to say what trifle may not lead to important discoveries, or that knowledge of no practical value to one generation may not be invaluable to the next. Meanwhile much material of great importance to anthropologists is disappearing all too rapidly, and we must search for knowledge and for truth while there is yet time. A philosopher of old has told us that Truth is great and shall prevail. Gentlemen, that philosoper was very clearly one great optimist, but even though we may see small sign of the prevalence of Truth in our generation it is all the more our duty as scientists to do all that in us lies to make her paths straight.

Sectional Addresses.

AGRICULTURE.

President: DR. F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.

INDIAN AGRICULTURE AND PLANT BREEDING.

ALTHOUGH much valuable work has already been done on breeding for increased yields and improved quality, very little systematic work has yet been conducted in India on breeding for resistance to disease. This is a very important line of work and would require the careful attention of plant breeders in the future.

One of the recent successes achieved at Pusa is the production of new types of *rahar* (Pigeon pea—*Cajanus indicus*) that would resist the wilt disease caused by *Fusarium*. The resistant hybrids are rather unique in that they possess the same morphological characteristics as the type which is susceptible to disease. The yield and the quality of wheat have been greatly improved by the work of the Howards at Pusa, but the problem of making it resistant to disease is still awaiting solution. There is perhaps no crop in India which suffers such heavy and consistent loss as wheat does from rust. A comprehensive scheme of work has therefore been undertaken by the Imperial Agricultural Department and it is hoped that fruitful results will soon be obtained. Extensive investigations have been carried out on linseed with the object of producing a white or yellow seed of high oil content and good yielding power. The results already obtained are not only of much practical interest but are also of considerable scientific value. Potato is another economic crop on which much systematic work has yet to be done for improving resistance to insect attack as also to fungus and virus diseases. On the plains there is considerable loss through fungus and bacterial diseases. The problem of storage has also not been solved satisfactorily. The varieties become degenerated and fresh seeds have to be obtained from time to time from the hills. On the hills, the crop is liable to blight from which the plants on the plains are generally free. Work has recently been undertaken at Pusa to study the distribution of different varieties of potato in India; to procure new varieties from South America and to cross them with the best Indian varieties for securing immunity or high resistance to blight, fungus and virus diseases; and to study the factors influencing flowering and fruit development as also those which might lead to the breaking of dormancy in the tuber. The most important achievement in the breeding of cane is the success achieved by Rao Bahadur T. S. Venkataraman and his colleagues in bringing about intergeneric cross between sugarcane and sorghum. Although it is premature to forecast the practical significance of that work, it would yet appear that one of the crosses (CO 352) appears very promising, ripening in six to seven months and maintaining its juice for another three months.

The physical mechanism of heredity lies in the cell and its chromosomes and a wealth of material awaits the investigator who can study the numerous crops which have been and are now subject to genetical research in India. The Central Agricultural Research Station which will soon be developed at Delhi will have a cytological section attached to it, but there is so much of work to be done that it may be hoped that the different Universities in India will also take active interest in that line of research and thus form fruitful link with the workers on the field.

There is a limit, however, to the extent to which the breeder can improve crop yield. The general soil fertility would be the limiting factor and it is necessary that if we are to obtain high yields of crops, we should also improve our methods of cultivation. The labours of the workers in the different branches of science are equally important in the advancement of the oldest and the most important industry in India.

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PHYSICS AND MATHEMATICS.

President: DR. N. R. SEN, D.Sc., Ph.D.

THE DEVELOPMENT OF MODERN THEORETICAL PHYSICS AND ITS LIMITATIONS.

A COMPARISON of the physical ideas of the days of Galileo and Newton and later of Laplace, Poisson, Coulomb, Oersted, Gauss and Weber on the one hand, and the modern microphysics with its Wilson chamber, quantum jumps, electronic phase wave and uncertainty relation on the other, shows that the construction of a bridge across the gap between them is well nigh impossible; all the same, there is a continuity between the old and the new. Thus in the newest Wave Mechanics the dynamical forms of Hamiltonian mechanics are preserved, while the Correspondence Principle of Bohr was avowedly an attempt to preserve some of the aspects of the older theory such as were not in contradiction with experiment.

In Newtonian mechanics the Laws of Motion and the Law of Universal Gravitation were the two central points which, however, had no interconnection and the equality of gravitational and inertial mass was only accidental. The Theory of Relativity, on the other hand, saw a unifying principle in this equality and developed a new Theory of Gravitation. Before this theory came, the science of mechanics ruled men's outlook on the external world, and attained a highly developed state at the hands of Lagrange, Hamilton and Jacobi. Another forerunner of the Theory of Relativity was the science of Electrodynamics. Maxwell's Field Equations, receiving a beautiful confirmation at the hands of Hertz, culminated in the advent of the Electron Theory of Lorentz, thus providing an Electrical Theory of matter while an earlier generation had sought to develop a mechanical theory of electromagnetism.

Summing up, the field theory succeeded in connecting electromagnetism with optics, generally identified the electron as a fundamental ingredient of matter and furnished a theory of Radiation which, apart from the question of the production of radiation and the distribution of energy in it, was found quite satisfactory. But there were a number of difficulties such as the constitution of the ether and a theory of the electron. The electron was found to require an infinite energy-content if it was thought of as a point charge, while when it was thought to have a definite radius, its energy and momentum did not

satisfy the usual relation between momentum and energy so that a part of its energy had to be thought of as non-electromagnetic. Poincaré also showed that a definite mechanical pressure on its surface was necessary if it were not to blow up.

While the laws of mechanics are invariant with respect to a Galilei transformation, the field equations of Maxwell are so only with respect to the Lorentz transformation. The Theory of Relativity was led to the validity of the Lorentz transformation even in mechanics by considering that time was also relative, and when the mathematical formulation of this was developed by Minkowski it was found that space and time were different aspects of one entity space-time. The successes of this theory led physicists to require invariance under the Lorentz transformation as the criterion of a correctly formulated natural law.

The Field Theory was found quite inadequate to explain the structure of the atom and its radiative properties. The existence of a line spectrum was incompatible with a stable atom if the radiation was supposed due to an accelerated electron. The sharp limit of the continuous spectrum of an X-ray tube, the dependence of the velocity of photo-electrons on the frequency of the incident light and the distribution of energy in the spectrum of a black body were each one of them in contradiction with the Field Theory and were explained only when the Quantum Theory was introduced. The most fruitful application of the quantum hypothesis was made by Bohr in his explanation of the emission of line spectra by stable atoms. His assumption of discrete energy states was confirmed by the experiments of Franck and Hertz, while his theory of spectra was extended and an explanation of the fine structure of optical and X-ray doublets and of the Zeeman effect was given by Sommerfeld. In all this work the mechanics of Hamilton and Jacobi was employed but an *ad hoc* quantum condition was super-imposed.

Heisenberg started with the object of excluding all unobserved quantities from the theory and was led to his Matrix Mechanics which removed a number of difficulties in the old Quantum Theory and dispensed with the *ad hoc* introduction of quantum conditions. The hypothesis of Uhlenbeck and Goudsmit that the electron has a spin moment of $\frac{1}{2}\times\frac{h}{2\pi}$ and a magnetic moment $\frac{eh}{4\pi mc}$ due to this spin, together with Pauli's exclusion principle that no two electrons can have the same set of quantum numbers, led to an explanation of fine structure, the periodic table and the anomalous Zeeman effect. The quantum mechanics makes use of non-commutative algebra and Dirac considered two types of numbers, the ordinary scalar numbers called c numbers and the quantum numbers or q numbers which are subject to special rules of calculation.

Very different in appearance but identical in the final results was the Wave Mechanics of Schrödinger which was based on de Broglie's idea that matter particles are associated with waves—an idea fully confirmed by the experiments of Davisson and Germer and of G. P. Thompson. Schrödinger's method is that of differential equations and eigenwert problems; the possible energies of the discrete states of the atom correspond to the eigenwerts of a differential equation which is really a wave-equation. Though this appears to establish a connection with the continuous theory, the later interpretation of the ψ-function leads to very different results. While in Classical and Einstein's Mechanics the position and momentum of a particle are quite determinate and any subsequent state can be predicted from the initial state, the dynamical variables in the new Wave Mechanics have no definite values but only a number of possible values with a certain probability for every one of them. Accordingly, the wave phenomenon associated with the probable values of dynamical variables has been called a Probability Wave.

This indeterminism is intimately connected with the uncertainty principle of Heisenberg according to which the errors Δp and Δq in the measurement of the simultaneous values of the momentum and position of a particle are such that $\Delta p.\Delta q$ is at least equal to h which is Planck's constant. This impossibility of reaching accuracy in both position and momentum coordinates is due to the fact that the physical process of measurement best suited for a determination of one of these introduces an unknown alteration in the value of the other. This is often described as a breakdown of the Causal Principle and has led to much discussion. While a Law of Nature states what particular event belongs to a given cause as its effect, the Principle of Causality states that a definite cause will have a definite effect. In the opinion of Planck who is a staunch supporter of Causality, an event is subject to Causality when it can be predicted with certainty. But infallible prediction is not possible in any case so that Causality has to be defined in a different way. In order to avoid the uncertainties inherent in every measurement the laws of Nature are supposed to hold exactly in an ideal world and the translation from such thought processes to the world of sense perceptions is supposed to be the origin of the uncertainty. But in quantum physics even this ideal process is shown to be subject to uncertainty. Accordingly Planck imagines a "Geist" who can perceive all details and can make certain predictions. Summing up, he says, that Causality is neither true nor false, but is a sort of heuristic principle which science must use in order to obtain fruitful results.

Schrödinger's non-relativistic wave equation with one wave function succeeded in reobtaining all the previous results in the one electron problem and in setting up a theory of dispersion and scattering. But the fine structure of alkali atoms came out wrong and there was no counterpart of the idea of spin. Besides, it was not invariant under the Lorentz transformation. Pauli in 1927 introduced two wave functions to correspond to the two values of the spin $\pm\frac{h}{4\pi}$. Dirac showed that using four wave functions the equation for the electron can be set up so as to have Lorentz invariance. The essential features of this theory are a current density vector satisfying the conservation principle and the existence of spin and magnetic moments of the electron.

Dirac also gave a theory of the radiation field. Since then attempts have been made to build up a quantum electrodynamics. The theory of Heisenberg and Pauli gives the classical results

but the self-energy of the electron comes out as infinite. The same difficulty occurs in a theory due to Dirac. The attempts of Klein and Jordan were also unsuccessful and Oppenheimer was able to show that the energy of interaction between radiation and the free electron also tends to infinity. Dirac's theory contained another difficulty, *viz.*, the existence of negative energy states. These were shown to be essential to the theory as when the Klein-Nishina formula is deduced therefrom. An attempt by Schrödinger to eliminate the negative energy states had to sacrifice the Lorentz invariance of Dirac's equation. Another difficulty is the conclusion reached by Klein that electrons of kinetic energy E, when they meet a potential barrier such that $eV > m_0c^2 + E$, can still pass through and turn up on the other side in the negative energy state. Sauter showed that an electron passes into the negative energy state if the potential changes by $\frac{m_0c^2}{e}$ within a distance $\frac{\hbar}{4\pi m_0 c} = 1{\cdot}6 \times 10^{-11}$ cm. The radius of the nucleus being less than this, electrons, if they can exist inside the nucleus, do not satisfy Dirac's equation. Dirac has sought to overcome the difficulties of the negative energy states by assuming that they are almost all occupied and that an unoccupied hole behaves as a positive charge and that when an electron falls into such a hole, it will dematerialise and give rise to two quanta. Even in this theory the self-energy of the electron is infinite and Dirac has made an attempt to overcome this difficulty by breaking up his operators into two parts and requiring that the part which leads to infinite self-energy should be omitted afterwards. But the principles of the conservation of energy and momentum break down in this theory as pointed out by Furry and Oppenheimer who also show that the theory is applicable so long as frequencies of the order of mc^3/e^2 or lengths of the order of e^2/mc^2 (radius of the electron) are not involved.

Another difficulty connected with the New Mechanics is that the loss of energy of electrons of initial energy 300×10^6 *eV* on passage through a centimetre of lead comes out from Bethe and Heitler's theory after all corrections have been made to be at least four and a half times the value found experimentally by Anderson. Though Dirac's theory is relativistic, the time appears in it in a different way from the space coordinates. A further difficulty of a fundamental nature pointed out by Landau and Peierls is that according to their calculation the uncertainty in the measurement of an electric field E is $\Delta E > \frac{\sqrt{hc}}{(c\Delta t)^2}$ and the idea of a photon itself is somewhat illusory. These difficulties still await an explanation.

Nuclear physics has advanced largely in recent years on account of the discovery of the neutron, the deuton and deuterium and the positron. Theorists have been confronted with a determination of the structure of the neutron. The view that it is made up of a proton and an electron leads to difficulties as also the view that it is a fundamental particle and that a proton is made up of a neutron and a positron. In the former case the fact that there is no solution to the wave equation with an orbit less than the first Bohr orbit presents a great difficulty, in the latter the positron will have to be assumed to have no spin and then the annihilation of an electron and a positron becomes unintelligible.

In all calculations regarding the conversion of one nucleus into another by bombardment and emission of particles the laws of conservation of energy and momentum and the Relativity principle of the mass equivalent of an energy E being E/c^2 have all been found to hold. Only in the case of β-disintegration there seems to be a violation of the energy principle in individual elementary processes. Bohr has pointed out that although the energy principle may be taken to be statistically valid, even then there will be difficulties. Pauli has tried to remove these difficulties by assuming the existence of neutrinos which, however, have not yet been observed.

Regarding Corpuscular and Field Theories of matter, Einstein and other eminent philosophers believe that a single field theory can account for all the facts. The first success of the general Theory of Relativity was the unification of the laws of motion and gravitation. Weyl and Eddington then tried to unite electromagnetism and gravitation in a unified field theory. Kaluza was able to do this by introducing a fifth dimension which, however, does not correspond to anything in physical nature. Einstein and Meyer have tried to develop a four dimensional unified field theory on the basis of the work of Kaluza. Einstein tried to explain the existence of a particle such as the electron in terms of his field theory but though he succeeded partly in doing so, his theory predicted the existence of electrons with all possible charges contrary to experience. The newest attempt in this direction is that of Born and Infeld who have revived a theory due to Mie in an improved form, and the existence of a point electron with finite energy has been found to be consistent with the theory. The success of this theory has been large and one awaits its extension to include quantum phenomena. On the other hand, there are physicists who believe that quantum phenomena cannot be brought into harmony with a continuous field theory and are trying to develop a quantum electrodynamics. The future alone can decide which of these ideas is going to give us a key to the secret of Nature.

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CHEMISTRY.

President: DR. A. C. SIRCAR, M.A., PH.D.

RECENT WORK ON THE HIGHER COAL TAR HYDROCARBONS.

IN his Presidential Address, Dr. Sircar gives a review of recent work on higher coal tar hydrocarbons especially acenaphthene, fluorene and phenanthrene. The discovery of a number of commercially important dyes among derivatives of acenaphthene has stimulated research in this group. In the benzene and naphthalene series, numerous products which have got any technical application as dyes, drugs, etc., are all substituted derivatives whereas in the case of the higher coal tar hydrocarbons, the quinones and their derivatives are of more value. The halogenated acenaphthenes can be oxidised to the corresponding acenaphthenequinones which give rise to valuable dyestuffs. The most important dyes in this series are probably the vat dyes obtained by the condensation of acenaphthenequinone with

hydroxythionaphthene and related compounds which are used for dyeing cotton or wool giving yellowish red to greyish black shades of extreme fastness. When halogens are introduced into the acenaphthene nucleus an added affinity for cotton together with light fastness and intensity is developed. Sircar and Rajgopalan (*J. Ind. Chem. Soc.*, 1932, **9**, 639) have obtained numerous vat dyes by condensing acenaphthenone with aromatic aldehydes, thus extending the work of Graebe and Jequier (*Ann.*, **290**, 195). Sircar and Guha (*J. C. S.*, 1924, 335) have described the azines obtained by condensation of acenaphthenequinone with orthodiamines which dye wool in brownish yellow to greenish black shades, and also oxazoles and iminoazoles obtained by condensation with aromatic aldehydes. On an examination of the constitutional formulæ of the 619 important azo dyestuffs, it was found that most of them contained sulphonic acid groups which though having no effect on colour, enhance the solubility and help in the development of even shades on textiles. It is possible that a thorough investigation of the mono- and poly-sulphonic acid derivatives of amino hydroxy acenaphthenes may yield valuable azo colouring matters. The poly-nitro derivatives of hydroxy acenaphthenes may also be found to be as useful as polynitronaphthols employed for colouring soaps, spirit varnishes and foodstuffs.

Fluorene ($C_{13}H_{10}$) occurs in the fraction of coal tar boiling at 300–340° C. Its methylene group in 9 position is remarkably active and a large number of derivatives have been obtained through this position. Holliday and Hodgkinson (*E.P.*, 1884, 3730) prepared hydroxyfluorene by alkali fusion of monosulphonic acid and described some azodyes. The tetra-azo compounds from 2 : 7 diaminofluorene and its derivatives couple with phenols and amines giving dyes which can be utilised for dyeing cotton but have, however, achieved no commercial importance.

Little is known of the possible quinones derivable from fluorene. Fluorenone and its derivatives obtained by oxidation of fluorene, afford a good field for research and until recently no dyestuff had been prepared from fluorenone (*J. Am. Chem. Soc.*, 1923, **45**, 3071). Sircar and his co-workers obtained fluorenone azomethines from 2-amino fluorene and aromatic aldehydes which though fairly deeply coloured were not suitable for dyeing. An attempt to prepare vat dyes from 2-amino fluorenone and dibasic acid chlorides also proved unsuccessful as the resulting fluorenoxylamides could not be made to yield soluble vats with hydrosulphite. Though satisfactory methods have been worked up for separation of fluorene in bulk from coal tar, no large-scale commercial use for the same has so far been developed. As with acenaphthene and anthracene, more interesting results have been obtained from the quinone of phenanthrene than from the parent hydrocarbon. A considerable amount of important work on dyes from phenanthraquinone is due to the late Dr. E. R. Watson and his school. They prepared polyhydroxy-, nitro-, and bromo-phenanthra-quinones, phenanthraphenazines but found their dyeing properties to be not very satisfactory. The anilinophenanthraquinones prepared by them produced dark-blue, green or black shades on wool. Their attempts to prepare vat dyes from this quinone were not successful. Watson and later Sircar described numerous azodyes from phenanthraquinone which were found to be mordant dyestuffs giving brown to violet shades. The azomethine dyes from phenanthraquinone were not found to be satisfactory for dyeing. The colour developed on the fibre by anilinophenanthraiminazoles was found to be influenced by the position of the anilino group, shades ranging even up to bluish black being obtainable. Dutt (*Ber.*, 1933, **66**, 1226) has recently prepared a number of indigoid vat dyes by condensation with hydroxythionaphthenes giving blue to greenish blue dyes.

Though a large number of phenanthraquinone derivatives have been described very few of them have as yet attained any commercial importance. Attention is drawn to the physiological and therapeutic importance of the phenanthrene nucleus as shown by its occurrence in the morphine group of alkaloids, in the sterols, the bile acids and even some of the hormones.

High temperature carbonization of coal is the main source of these higher coal tar hydrocarbons. Dr. Sircar considers there is no reason to be discouraged if a continued supply of these products is threatened by a general adoption of low temperature carbonization. He concludes his address with an optimistic note that in case of scarcity the inventive genius of the technical chemist will produce these compounds on a commercial scale employing synthetic methods already known, as has been done recently in the case of anthraquinone and methylanthraquinone.

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ZOOLOGY.

President : DIWAN ANAND KUMAR, M.A.

SPICULES AND CLASSIFICATION OF TETRAXONIDA.

As early as 1900, Minchin classified the phylum Porifera (sponges) into Calcarea, Hexactinellida and Demospongia and of the four sub-classes under Demospongia, Tetraxonida forms an important one. Five years later, Dendy divided the non-calcarea into 4 orders, *viz.*, Myxospongidæ, Triaxonida (Hexactinellida), Tetraxonida and Euceratosa. The address before the Zoology section is a chronological account of the spicules and classification of one of these important orders of non-calcarea, namely, Tetraxonida, where the fundamental plan of the spicule is tetraxonid and tetractinellid. The learned president claims a certain amount of familiarity with the subject though he rightly points out that even here he can only speak " as a person, who has gathered information from different sources, rather than as one with any authority." The spicules of the tetraxonid sponges are usually treated under 2 categories—megasclere and microsclere. The former are skeletal in nature while the latter lie scattered in the softer parts and according to Sollas the larger forms are derivatives of the microsclere. Describing the Homosclerophera, an exhaustive account of the spicules is given of the three genera Plakina, Plakortis and Dercitopsis. In the last genus spicules with 2-rays upto pentacts are noticed. This genus is possibly the progenitor from which more complicated forms must have evolved. The spicules in the species of Plakinidæ show various combinations of forms of those met with in the above-named primitive form and the mega and microscleres become very prominent. Several forms

of triænes (including some aberrant forms) of diactinal types are described. Under the microscleres, the astrose and sigmatose types are largely treated, giving a comprehensive account of the variations that these may undergo. The appearance of spines on these spicules is also mentioned. At the end the classification of this group according to various authors is appended.

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BOTANY.

President: DR. J. H. MITTER, M.A., B.Sc., PH.D.

FUNGOUS PLANT PATHOLOGY AND MYCOLOGY IN INDIA.

IN his Presidential Address to the Section of Botany Dr. J. H. Mitter has given an exhaustive account of mycological and plant pathological research in India.

He has traced the history of mycological work in India from 1825, which was mainly of the nature of collections, to the present day. The impetus to higher research in Plant Pathology in India may be said to start with the investigations of Dr. E. J. Butler, "the real father of Mycology and Plant Pathology in India".

The important rôle played by the Imperial Research Institute, Pusa, with Dr. Butler as the Imperial Mycologist can be seen by the large number of valuable publications. In the course of his address, Dr. Mitter has reviewed, more or less in detail, the investigations carried out on Plant Pathology at the Imperial Agricultural Institute, Pusa, and in the Provincial Agricultural Departments at Madras, Mysore, Baroda, Bombay, Central Provinces, United Provinces, Assam and the Punjab. The research work done by the Indian Tea Association and that by the Forest Departments in India are mentioned in review. One feels that he might have included the very valuable contribution on Coffee Research made by the Scientific Officers of the United Planters' Association, South India, at the Coffee Experiment Stations at Siddapur and Balehonnur.

At present some of the Universities, *viz.*, the Punjab, Agra, Allahabad and Calcutta, have taken up research on fungi. In considering the future of Mycology in India, considerable stress is laid on the need for co-operation between Universities and the Plant Pathologist, who has not always much time at his disposal to carry out the purely scientific work on the life history of the pathogen.

He has also suggested that the sons of rich zamindars should take up to Plant Pathology not only as a hobby but to increase the yield from their land.

These valuable suggestions of Dr. Mitter in the interest of Plant Pathology in India, will find a wider application for many other problems of agricultural research.

In conclusion, he has pointed out the desirability of establishing a bureau for stock cultures of fungi, and the publication of an up-to-date textbook on Mycology for India.

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GEOLOGY.

President: DR. M. S. KRISHNAN, M.A., PH.D., A.R.C.S., D.I.C.

THE DHARWARS OF CHOTA NAGPUR—THEIR BEARING ON SOME PROBLEMS OF CORRELATION AND SEDIMENTATION.

THE Presidential Address to the Section of Geology by Dr. M. S. Krishnan of the Geological Survey of India deals with a subject of considerable importance to Indian geologists, *viz.*, the correlation of the rocks of the Dharwar system and a discussion of the origin of some types of rocks found therein. The Dharwars of Chota Nagpur are divided into three series: The lower 'Metamorphic series' consists of much igneous and some sedimentary material, and is confined to South Singhbhum and the adjoining part of Keonjhar; the middle 'Gangpur series' is characterised by manganese ores of the gondite type and calcitic and dolomitic marbles; the upper 'Iron-ore series' is characterised by banded hæmatite-jasper with associated iron ores and basic igneous rocks, mainly sills and flows. On the basis of this classification, the Older Dharwars are to be looked for in the metamorphics of other parts of India. The Middle Dharwars comprise the Gangpur series of Bihar and Orissa, the khondalites and associated marbles and manganese ores of the Eastern Ghats region, the Sausar series, the Sonawani series and the lower part of the succession in Jubbulpore in the Central Provinces, the Aravallis and Champaners of Rajputana and western India, and the Sakarsanhalli rocks of Mysore. The Upper Dharwars will include the Iron-ore series of Singhbhum, the Chilpighat series of Bilaspur and Balaghat, the Sakoli series of Bhandara, the iron-ore-bearing rocks of Bastar, Chanda and Jubbulpore, and probably the greater part of the so-called Bijawars of Bihar. The Dharwars of Southern Bombay, Bellary, Mysore and Salem, in which typical iron-ore rocks occur, and possibly also the Delhi System of Rajputana, are to be included here. A concise description of the rocks of Bihar and Orissa and Central Provinces is followed by a discussion and a tabular statement giving the correlation suggested above.

The latter part of the address concerns itself with the description of the chief characters and a discussion of the mode of origin of a few types of rocks—the marbles, carbonaceous phyllites, manganiferous rocks and the banded ironstones. The marbles, which are to a large extent dolomitic, are regarded as chemical precipitates, but primitive organisms may have aided their formation. The Carbonaceous phyllites are held to be ordinary sediments, whose carbon content was derived from early organic matter, and not from a volcanic source. Similar carbonaceous rocks are found in the Salkhalas and Jutoghs of the Himalaya, and the Chaung Magyis and Merguis of Burma, the carbon content of all these being attributable to organic and not volcanic origin.

The manganiferous rocks comprise two types. The older gondite type is primary and the younger Iron-ore series type is secondary, as shown by Dr. Fermor in his well-known work on the manganese ores of India. These two types also occur in other parts of the world, and when both are found in the same region, as in Brazil, the

older which is also richer in manganese than iron, is of the gondite type.

The banded iron-ore rocks are briefly described and their constituents are held to be essentially the products of weathering under the conditions existing in the Pre-Cambrian era. The iron content cannot be regarded as of volcanic origin especially as the period of volcanism has been shown to be later than the period of their deposition. The carbonate and oxide facies of the deposition of manganese and iron ores have been controlled by physico-chemical conditions, among which the relative abundance of oxygen and carbon dioxide in the areas of deposition has played an important part. It is also suggested that the magnetite-quartz-schists of Mysore are of sedimentary origin and not igneous as held by the Mysore geologists.

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MEDICAL AND VETERINARY RESEARCH.

President: MAJOR K. R. K. IYENGAR, M.D., D.P.H., I.M.S.

RABIES.

RABIES has been known to mankind for over 2000 years. A considerable amount of time has been devoted to work in connection with rabies, but little of immediate value has been ascertained. All attempts to cultivate the organism artificially have failed, and all efforts to prepare serum and devise more efficacious means of prophylactic treatment than those in general use now have ended in disappointment. Until the organism has been cultivated artificially, it will not be possible to improve greatly upon the somewhat crude method which is now employed. All future research work on rabies should concentrate on the identification of the virus and its growth on artificial media. Once this is done, the necessity for so many Pasteur Institutes in India will not exist. One All-India Pasteur Institute, whose functions would be to manufacture the vaccine and to carry out research work, would be sufficient.

Last year, work was carried out at the Pasteur Institute, Coonoor, in order to find out the electric charge carried by the rabies virus and the method adopted for this purpose involved the use of electrophoresis. The experiments consisted in passing a 4-milliampere current through a 5 per cent. suspension of infected rabbit brain in sheep serum, and, after a time, samples collected at each of the poles were subjected to appropriate biological tests. It was found that the contents of the positive cell produced rabies on subdural inoculation to rabbits, while the contents of the negative cell did not. This clearly proves that the rabies virus is electro-negatively charged and migrates towards the positive pole, within certain limits of pH.

In view of the great difference of the virus-content of the different parts of the brain, the vaccine as used now can only be taken as a crude one. Now that we know that the virus has an electro-negative charge, we can isolate the virus in a pure form at the positive pole, thereby getting rid of the tissue proteins. This may be the means of preparing a more highly concentrated anti-rabic vaccine than has hitherto been possible. Further experiments as to the antigenic value of this vaccine as compared with that of the crude vaccine are in progress.

We have also found that the vaccine can be sterilized by exposure for 10 minutes to radiation from a quartz mercury lamp and the antigenic value of the vaccine so inactivated has in no way deteriorated. A mercury vapour lamp gives radiation of wave-length from 6500 A. U. to very nearly 1800 A. U., and there is evidence that the shorter wave-lengths of light, such as ultra-violet 4000 to 1800 A. U. are highly inactivating. This method of sterilizing the vaccine is a great advance on the present methods adopted by the use of chemicals, such as carbolic acid and formalin.

By far the largest proportion of persons who come to anti-rabic institutes for treatment have been bitten by dogs. Dogs must, therefore, be regarded as the chief agents in producing mortality from hydrophobia in man. Jackals inflict about 5 per cent. of the bites; cats a still smaller proportion: whilst other animals may be left out of consideration. If rabies amongst dogs were to be practically eliminated, not only would the greater number of deaths from hydrophobia in man be prevented, but also a large number of cattle and domestic animals would be saved. Stray dogs, when rabid, set up foci of infection here, there and everywhere, until they succumb to the disease.

It will not be possible to suppress rabies completely in a country like ours within a reasonable number of years, but it can be controlled sufficiently to reduce the annual mortality to an almost negligible quantity. Rabies primarily is a disease of dogs; only occasionally is it communicated to other animals and to man. It is a wrong procedure to treat cases as they arise and to take no steps whatever to control the dog population. Many anti-rabic institutes have been established for curative purposes, while preventive measures have been neglected. This is wrong in principle. Steps should be taken to deal with the disease at its source.

In Germany, rabies has been so successfully controlled that it is now regarded as entirely a frontier disease, that is to say, every case in man and animals can be traced to an importation, and rigorous preventive measures are promptly taken. In Australia, rabies is now unknown. In the British Isles, the muzzling order was introduced, followed by the quarantine of all imported dogs, and this has resulted in the eradication of the disease within a few years. At the time there was a public outcry against these orders, but yet the end justified the means, and persistence was crowned with success.

To control rabies, dogs must be controlled, and if any class or individual is beyond control, they must be gradually eliminated and not allowed again to come into existence. In this endeavour the State and the public are interested and earnest co-operation is necessary on all sides, if anything is to be achieved in the way of regulating the dog nuisance and the danger from rabies. Any scheme to be effective must have the hearty co-operation of all the authorities concerned. It would scarcely be worth while to attempt any measures of control, unless they were adopted universally in the land. All dogs which have no real owner who will accept any responsibility for them, are under no control and they must all be destroyed. There is a very large class of dogs which are attached to no

house or person, and procures an insufficient supply of food from the garbage of towns and villages. A misguided sentimentality prevents the destruction of these stray dogs. No other animal is as intimate psychically and physically to man as the dog. Rules and regulations to control the dog population should appeal to both dog lovers and humanitarians. The neglect of this simple remedy for such a dread disease, which is 100 per cent. fatal, reflects upon the logic and intelligence of ourselves and our contemporaries.

Registration and licensing of dogs must be enforced by all municipalities and district boards. The licensing fee must be fairly high to prevent persons who can ill-afford to keep dogs from owning them. Any person possessing a dog without a license must be heavily fined. Lethal chambers must be established for the destruction of all ownerless dogs. Clubbing, poisoning and the shooting of them in the streets are out of the question. All railway companies should make arrangements to destroy stray dogs found in railway station premises.

In rural areas, besides the destruction of stray dogs, jackals also should be destroyed, as no doubt a certain percentage of dogs get their infection from this source.

No useful purpose would be served at the present time by the quarantine of dogs imported from foreign countries, while rabies is so prevalent within the land. Only when we have perfected the system of controlling the local dog population, should attention be paid to the quarantine of imported dogs. At present, most of these dogs come from Australia and England where no rabies exists.

During recent years, almost all the Pasteur Institutes in India have been using a more concentrated vaccine for treatment. Since the introduction of the higher dosage, there is a significant fall in the mortality rate.

Anti-rabic treatment should be decentralised to the utmost extent possible, so that persons bitten by dogs could have treatment nearer their homes.

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ANTHROPOLOGY.

President: DR. G. S. GHURYE, M.A., PH.D. (CANTAB.).

ANTHROPOLOGY AND OUR EDUCATIONAL SYSTEM.

THE subject of Anthropology is still new and strange enough to evoke different reactions in the minds of different people. To the lay man it conjures up pictures of skulls and other bones, sometimes of the "weird" customs of "savage" peoples and "curious" implements of stones and bones. The explanation of this popular conception lies in the growth of this science and in the fact that it comprises three branches dealing with aspects of man's history which are not as yet properly integrated in the courses of study in Anthropology and in the practice of professed Anthropologists. Anthropologists have not paid as much attention as the importance of the subject deserves to the social and cultural history of ancient and modern civilizations. The use of this science as conceived by the great British Anthropologist Tylor assumed a very wide scope of the subject. Anthropology was to be a guide for bettering social life. To this end inclusion of a proper study of the social and cultural history of the peoples of mankind, uncivilised and civilised, past and present, is quite essential. Such a study is bound to convince people of the reality of culture-contact, and of the part such contact has played in the shaping of civilizations. That culture does not progress uniformly but shows cycles of advance and regress, that certain highly developed cultures have perished while other peoples who had but the rudiments of culture have made great progress are very important lessons for us Indians. Our younger generation imbibing these lessons will develop a correct attitude towards the situation which has arisen out of contact with Western civilization. We need not be downhearted and actuated by inferiority complex. Nor should we develop a sense of superiority and self-complacence. We have amongst us a fairly large number of primitive tribes whose assimilation in our culture is a problem of great national importance and is one which ought to be studied with the help of expert Anthropologists. Our approach to the much-needed social reforms must be changed. Instead of appealing to the old scriptures for suggested reforms we must appeal to lessons from the history of humanity. For thus only a rational attitude towards social change—a crying need for all societies—can be created. In view of the great cultural and intellectual value of Anthropology and Sociology it is earnestly suggested that these subjects should be introduced in all courses of study which are likely to be taken up by students who in their future careers will become leaders of society in one capacity or another.

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PSYCHOLOGY.

President: Dr. S. C. Mitra, M.A., D.Phil.

PSYCHOLOGY AND LIFE.

PSYCHOLOGY deals with mental processes. As a natural science it has made considerable progress within the last fifty or sixty years. Investigations are not confined now to the mere academic discussions of what a feeling is, or how one remembers; but efforts are directed towards making the theoretical knowledge gained serviceable in the practical fields of life. The art of curing physical illness is considerably helped by the researches in the science of Physiology; so also the task of treating mental maladies is much facilitated by the discoveries of modern Psychology. A disease, whether physical or mental, is after all a want of proper balance. Men live in societies. A society is an organism which means that there is mental interdependence and no one can live without the help of others. Men's actions are directed towards maintaining this harmony. A trait in a man's character becomes a diseased trait only when the presence of it leads to actions which tend to disturb this equilibrium. A diseased trait therefore may be described as not only an abnormal trait but an anti-social trait. How these anti-social traits develop in particular persons has been made clear to us by Psychoanalysis, and as knowledge is power, we are now in a better position to combat these mental diseases, which unfortunately are on the increase in many countries, our country not excepted.

Everybody recognises that proper education is one of the best methods of removing the maladjustments that we see around us everywhere. Psychology enables us to measure with some

degree of precision the innate aptitude and capacities of a boy or a girl and thus to indicate the type of education that is suited to him or her as also the avocation of life for which he or she is best fitted. A good deal of energy which is now lost in trying to fit a square peg in a round hole is thus saved.

In the spheres of Industry and Commerce, in the wider circle of international relations as also in the narrower circle of family life, psychology is capable of rendering much useful service. In our country, however, the knowledge that has been gained is running into waste for want of proper organisation. It is urgently necessary, therefore, that an Institute of Applied Psychology be founded here as early as possible whose duty it would be to undertake actual large-scale work for the benefit of society as has been done in many other countries. The problems of life in our country are no less keen and acute than in other countries, and if the utilisation of psychological knowledge has been helpful in other countries, there is no reason why such a method should not be adopted here.

Diseases of Sugarcane.

The Antigenic Properties of the Sugarcane Mosaic Virus.—Dr. S. V. Desai in an interesting paper read before the Section of Agriculture of the Indian Science Congress, discusses the results of serological tests with "anti-mosaic" and "anti-healthy" juice sera. Rabbits were immunized by inoculating with increasing doses of Chamberland Candle filtrates of mosaic and healthy leaf juices intravenously. Anti-mosaic and anti-healthy juice sera were used for precipitation and other serological tests. Anti-mosaic serum inactivated the mosaic leaf juice while anti-healthy serum had no effect as was proved by inoculating ten plants with each of the sera-mosaic leaf juice mixture. All plants inoculated with anti-mosaic serum and mosaic leaf juice mixture remained quite healthy while the similar mixture with anti-healthy serum was infective to the plants inoculated. Precipitation tests with diluted sera and leaf juices showed that the anti-mosaic serum gave a positive reaction with mosaic leaf juice and negative against healthy leaf juice. Anti-healthy, however, gave positive reaction for both leaf juices, though the reaction was faint in both the cases. This may be due to the antigenic properties of the plant protein present in the leaf juice used for immunizing the rabbits. The plant juices used as antigen did not give Millon's, Biuret and other protein reactions. The nitrogen in the juices was found to be ·01 per cent.

A New Disease of Sugarcane.—Dr. Desai has recorded his observations on *a disease of sugarcane* observed at Musheri Sugarcane Research Station. The symptoms of the disease were wilting of the canes and rotting of the plant from top downwards with a strong smell of fermenting debris. The disease appeared during monsoon, the affected plants rotted very quickly and the stem became a mass of semi-solid stinking pulp. Hence it is named 'Stinking rot'. The causative organisms were isolated and studied. Two types of Bacteria were found in the affected tissues. One was pathogenic and the other saprophytic but the mixed cultures were found to be much more effective in bringing about the disease by artificial inoculation.

Biochemical and cultural reactions of the pathogenic organisms were allied to organisms of the Pyocyaneus group but differed from *Phy. Xanthochlorum*, *B. Aptatum* and *B. Marginale*, which represent the allied pathogenic types of this group.

The organisms were non-pathogenic to potato, beans, tomato, tobacco, and other plants tried. The pathogenicity was only confined to sugarcane. The infection in plants is supposed to be through top shoot borer holes. The 'dead heart' formed a suitable medium for mass development which initiated vigorous rotting, some plants being killed within a fortnight.

A Biologist's Philosophy of Life.

A Biologist is proud of the achievements of science, but humble before the mysteries of nature. He respects truth more than authority. He rates evidence above theory, but nevertheless attempts to progress by the use of constructive imagination. He strives to be open-minded, tolerant, critical but kindly, courageous but cautious. He looks forward cheerfully to a life of hard work and expects to be methodical, painstaking, accurate, persevering—and modest because he believes that his profession is most honourable and that his own carefully-considered endeavour is worth while. He feels an obligation to keep alive by study, discussion and thought. If he attains honour, he has ideals, ambition, wit and common sense and is somewhat a gentleman of culture. Like any man he needs an avocation, but he must seriously attend to his business in life and plan to be the best possible in his chosen field—industrious, well informed, thoroughly trained, alert and active; a swimmer and not a floater.

A biologist thoughtfully chooses a field in which he can raise problems. He fertilizes his plots with carefully tested mixtures of thought, knowledge gleaned from books and journals, suggestions from colleagues, and eternal painstaking. He waters them with the sweat of his brow. When some of his cherished projects flower and bear fruit, he is glad—and writes a paper or discourses. Perhaps his friends say, "It is good. This man has added to the sum of knowledge. Up and on!" This is his reward.—DR. ARTHUR SPERRY PEARSE.

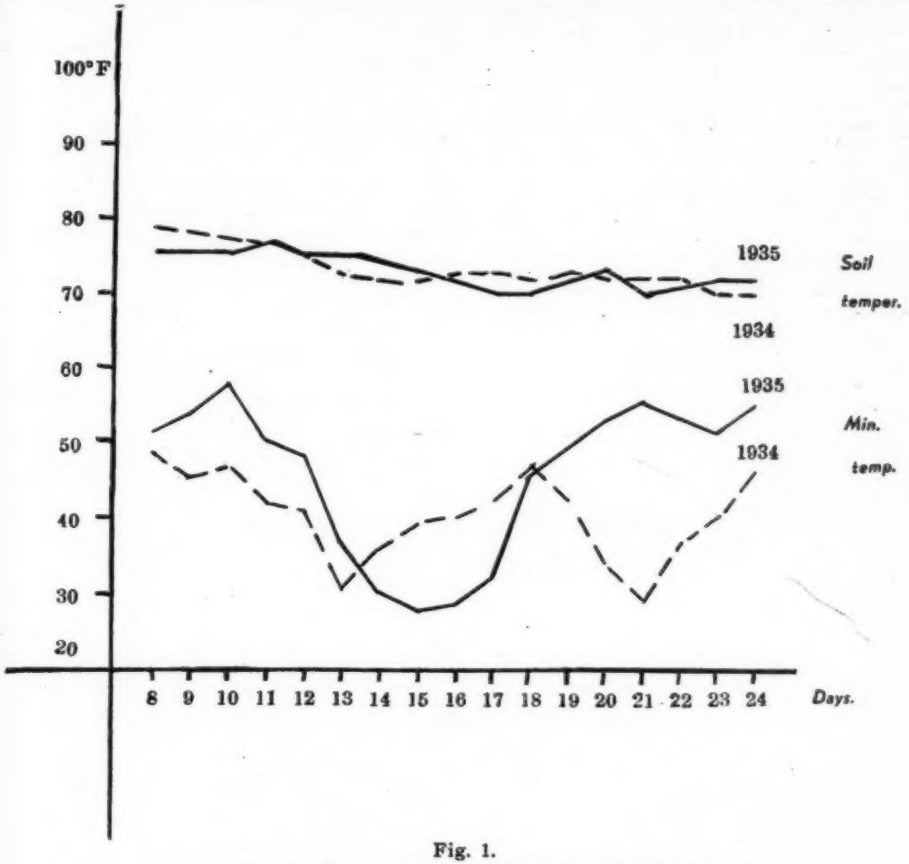

Fig. 1.

Minimum and soil temperatures for 1934-35 during the frost period.

From amongst the weeds *Crotolaria retusa*, *Mallugo hirta*, *Ocimum canum*, *Vioca auriculata* and *Trichodesma zeylanicum* suffered total destruction while the loss to *Celosia argentea*, *Leucas aspera*, *Cassia occidentalis*, *Bergia odorata*, *Cyperus rotundus* and *Phyllanthus Niruri* ranged from 10 to 90 per cent.

It may be noted that the soil temperatures up to 1 foot or below never went below 70° F. and injury had been mostly to the aerial parts of the plants. All the plants sprout fresh after the regain of the normal temperature but without any economical advantage.

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and
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Baroda,
February 13, 1935.

The Roots of *Psaronius*, Intra-Cortical or Extra-Cortical ?—A Discussion.

IN a preliminary note with the above title communicated last November to the Indian Science Congress and read before the recent Calcutta session (January 1935)[1], I wrote as follows:

" In the root-region of *Psaronius* generally two zones can be distinguished: an inner zone of relatively small roots which are very crowded and

sometimes flattened in consequence, with a 'packing' of thin-walled filamentous cells; and an outer zone of larger, obviously extra-cortical, free roots, which are not distorted by mutual pressure. The inner roots were formerly regarded as intra-cortical, but since 1902, after Farmer and Hill (see discussion in Scott, *Fossil Botany*, 1920, **1**, 271-275), the view has gained ground that they are also extra-cortical, the filamentous tissue being regarded as the compacted hairs derived from the roots themselves. This view was confirmed by Solms (1911)[2] " [and, I may add, accepted by the late Dr. D. H. Scott].

" After an examination of some material from Chemnitz[3] the writer has been led to believe that the intra-cortical view was after all the correct one, and that Stenzel's interpretation best meets the observed facts. Along the outer border of the inner zone the writer finds many places where there is an unmistakable compact periderm-like tissue, in places a dozen cells deep, with the cells serially arranged [see Figs. 1, 2]. This 'periderm' is not in a continuous band all round but this seems to be due to the fact that here and there the inner roots are bursting out through it so as to become free."

" The absence of leaf traces among the roots cannot be questioned but is explicable on Stenzel's view that 'the embedding tissue is a secondary zone, developed *pari passu* with the growth of the roots after the leaves had fallen' (Scott, p. 217)."

The object of the present communication is to bring forward some further facts in support of Stenzel's view. I confess that although Stenzel's interpretation probably offers the best available solution of the problem, even this at first seemed to me rather far-fetched. I knew of no other plant, living or extinct, which showed the unusual mode of growth visualised by Stenzel; and although I have had the main facts before me for over three years, I did not feel quite convinced.

However, as stated, my preliminary note was communicated in November, and I was hoping shortly to write a fully illustrated description of the facts, for whatever they might be worth, when indirect support for Stenzel's view came in from an entirely unexpected source, namely, a living member of the Liliaceæ, *Asphodelus tenuifolius*.

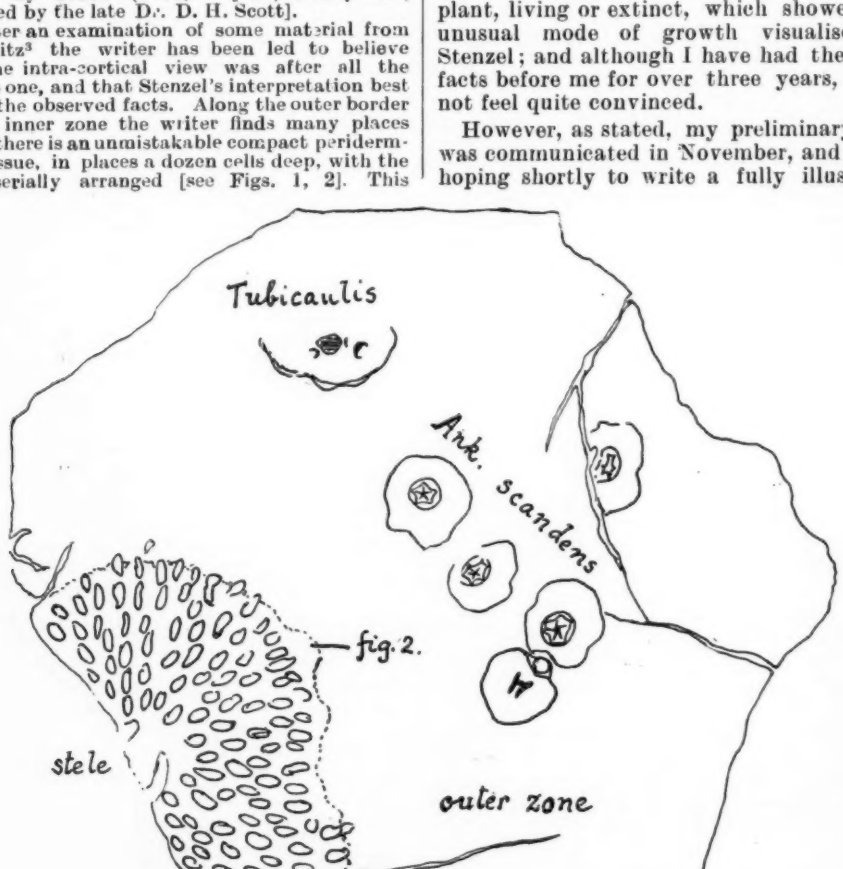


Fig. 1.

Outline sketch (diagrammatic) of cross-section of *Psaronius* sp., showing the position of the periderm (dotted line). Among the extra-cortical roots (outer zone) are several epiphytic stems and roots of *Ankyropteris scandens* and *Tubicaulis Berthieri*. Nat. size.

SUPPLEMENT TO "CURRENT SCIENCE".

Energy and Economics.

By Gilbert J. Fowler, D.Sc., F.I.C., F.R.San.I.

AT the close of a lively discussion on what has now come to be known as the "new economics", which was reported at length in the *Madras Mail* of December 10th, 1932, the following question was asked—"How can a thing the supply of which is infinite have any economic value at all? And, how can anything which has no economic value be used as a standard of value?" The reply was a further question—"You see that ray of sunshine. What is its value?" Reply—"I do not know" (Laughter). Counter reply, "Nor do I" (roars of laughter). "But that does not make it valueless!" (Renewed laughter).

This entertaining episode awakened numerous "pensees d'escalier" in the mind of the present writer, and some of them, after the passage of two years, and careful watching of the intervening trend of things, find expression in the present article.

In the first place one ray of sunlight, falling upon a photo electric cell could cause a flow of current which could operate dangerously or usefully according to the character of the mind by which it was controlled. Thus the energy from the far star which was made to set in motion the mechanism which opened the Chicago Exhibition, might equally have been the means of firing a mine. In either case the amount of energy expended is perfectly measurable.

Of greater fundamental importance is the fact that such a ray of sunlight falling upon a green plant cell liberates biotic energy, and the plant *grows*. It is estimated that with the assistance of solar energy plants convert per year 60 billion kilograms of carbon dioxide into useful organic substances. Even so only one ten thousandth part of the total solar energy received on the surface of the earth is thus utilized. Moreover this enormous photosynthetic activity is capable of being doubled if caused to act intermittently with a sufficiently rapid alternation of light and dark periods.

It must be remembered further that it is solar energy which lifts the water of the seas and brings it down as rain, which by the labour of man, itself derived from the energy of sun-raised food, can be stored and used to give life to the growing crop, and to turn the turbines through which the solar energy reappears as mechanical and electrical power.

Although therefore the supply of solar energy is virtually infinite, its value cannot be denied.

It has been calculated indeed, on the basis of figures given by Sir James Jeans, concerning the weight and value of *photons*, that we are actually receiving £50,000,000,000,000 worth of sunlight a day. The earth takes delivery from the sun of about 160 tons of sunlight a day and a pound of sunlight if supplied through a meter in the manner of electrical energy would cost £100,000,000. The only manner of utilizing the sun's rays directly so far has been in the form of heat, and great improvements have recently been made in sunshine boilers and furnaces. The schemes which have been undertaken with the object of using the heat of the surface water of tropical seas by heat exchange with the cooler water of the depths, have not so far been reported as successful, owing to some unforeseen mechanical difficulties, but such a process is not inherently impracticable and ultimately may lead to a further increase of the enormous store of energy available to the modern world.

That energy can be used as a *measure* of value is clear from the fact that the kilowatt hour, the unit of electrical energy, has been used successfully by The Victoria Falls and Transvaal Power Company as the unit of their accountancy for nearly a quarter of a century.

There would seem to be, as often happens in discussion of economic questions, some confusion of terms in the question referred to at the outset of this article. When the questioner asked whether anything, the supply of which was infinite, could have any economic value at all, what may have been in his mind was not value but *profit*, which is quite a different thing.

On the occasion of the miracle of the loaves and fishes, when it is recorded that all had enough and to spare, since several baskets of fragments were collected after

the repast, there was *value* there for every hungry mouth, but the only way in which there could be any individual *profit* would have been if certain "rugged individualists" had rushed the camp and held up supplies until they had obtained their *price*.

Objection may also be taken to the term *standard* of *value*. Value fluctuates with circumstance and desire. Jewels once highly prized become unfashionable, and the price sinks to a small percentage of the original, though the jewels are unchanged. A perfume once plentiful becomes, through some change in natural conditions, very scarce, and consequently increasingly valuable. Such fluctuations can however be met without dislocation of the economic system if the token or *basis* of value remains unchanged. If however the buyer, *e.g.*, of the depreciated jewellery undertakes to buy it for so many rupees and the seller sends a bill in which the rupees figure as pounds there can be no reasonable business. Or if goods are invoiced by the Bombay Maund (28 lbs.) and paid for as so many Bengal Maunds (74 lbs.) there must be trouble.

A fixed basis of *accountancy* is therefore necessary and this cannot be found in a commodity the value and quantity of which is constantly varying. It is as if travellers having made arrangements for their journey on the basis of the fares given in the company's timetables, were to find either that there were no tickets to be had, or that the price had greatly increased, owing to the scarcity of the paper of which the tickets were made, though all the time the train was awaiting them with plenty of accommodation.

Such a procedure would be equivalent to cornering theatre tickets while the house was only half full and there was a long waiting queue outside. This operation is said to be a criminal offence in Mexico.

The confusion therefore in the discussion with which this article opens is between *money* and *wealth*, and also between *value* and *profit*.

The connotations of these words like many other words concerned with fundamental conceptions, have varied through the ages according to the level of perception reached by the thinkers of the time.

According to Prescott (*History of the Conquest of Peru*), the ancient Incas would have seemed to have reached a higher level of understanding than their Spanish conquerors. In the first place they realized the fundamental importance of agriculture. Every man, except the privileged classes, was required to assist in the cultivation of the land. The Inca himself did not disdain to set the example. On one of the great annual festivals he proceeded to the environs of Cuzco, attended by his court, and in the presence of all the people turned up the earth with a golden plough, thus consecrating the occupation of the husbandman as one worthy to be followed by the Children of the Sun. One cannot help but be reminded of Il Duce, who in similar, but more homely and democratic manner, has encouraged the Italian cultivators.

Gold in the Inca economy was valued for its beauty, it was not used as money but was lavishly employed to decorate the Temple of the Sun, and marvellous workmanship was displayed in these adornments. This workmanship was lost upon the Spanish conquerors who caused the Indian goldsmiths to melt down the work of their own hands into bars of gold. At the sack of Cuzco, Prescott writes: "Every article rose in value as gold and silver the representatives of all declined. Gold and silver in short seemed to be the only things in Cuzco that were not wealth."

This vandalism has alas not been confined to the Spanish conquerors. In the exceedingly interesting Supplement on Gold published by the *Times* in June 1933, it is stated that the exquisite work of early goldsmiths is now very rare, owing to the majority of the pieces having been melted down for bullion by various warring armies. Possibly some of these ravages may have been present in the mind of Milton in his description of Mammon.

> "*Mammon*, the least erected Spirit that fell
> From heav'n, for ev'n in heav'n his looks and thoughts
> Were always downward bent, admiring more
> The riches of Heav'n's pavement, trod'n Gold,
> Than aught divine or holy else enjoy'd
> In vision beatific."

The words of Prescott concerning the Spaniards in this connection, are also worthy to be quoted: "The wealth thus suddenly acquired, by diverting them from the slow but surer and more permanent sources of national prosperity, has in the end glided from their grasp, and left them among the poorest of the nations of Christendom."

There would seem to be an analogy between the ideas of wealth entertained before the days of Adam Smith, and the ruling notions of the scientific world before

the time of Dalton and Joule. To consider wealth as gold, resembles the thought of heat as *caloric*, a definite substance. The present writer derived his early ideas of energy from Tyndall's classic volume "Heat a Mode of Motion", a title which indicated that such a conception of heat was still by no means universal. It is little more than a century ago that terms such as *phlogiston* and *caloric* were current in scientific literature. They belong to the same static sense of things as is expressed in the "wages fund" theory of Bentham and others, so caustically criticised by Karl Marx. Marx himself however appears to argue that the "Value" of commodities depends exclusively upon the amount of labour involved in their production, and he goes on to contend that the labourer produces more than is necessary for his subsistence, and that the rest of his product passes to the capitalist, who has bought his labour power for a subsistence wage. This is his main charge against the capitalist system, that while it encourages production, the profit of the production goes to the capitalist and not to the workmen. Unfortunately economic history has largely confirmed the conclusion of Marx. The proof of this is a simple matter of statistics. Thus in the 1911 edition of Chiozza Money's "Riches and Poverty", the following data are given: Taking figures for 1900 as 100, by 1908 wages have only risen to 101 nominal, an actual drop in real value, whereas profits have gone up to 112½. Between 1893 and 1908 nominal wages increased by 12 per cent. and profits by only ½ per cent. short of 30 per cent. which means that the capitalist has managed to get approximately two and a half times the nominal increase of the workman's takings, and in real values to get all, or more than all, of whatever increase may have been harvested.

It is over Marx's proposed remedy, namely, the Dictatorship of the Proletariat, or of the working classes, that there is room for serious discussion. After all, it is President Roosevelt who says, "I do not believe that in the name of that sacred word, individualism, a few powerful interests should be permitted to make industrial cannon-fodder of the lives of half the population of the United States."

Henry George looked upon *land* as a fundamental factor of production and believed that if the possession and control of land could be in the hands of the people, *i.e.*, the State, it would be the cure for economic troubles. Without "a man to till the ground," land in itself has, however, little value as wealth. Marx's workmen without the assistance of the machine, itself driven by solar energy, either conserved in coal, or collected in the turbine, can accomplish little, but on the other hand, energy, without direction by intelligence, is a blind force.

It has been said that if only one sentence remained of his writings still Ruskin must be recorded as a prophet; the sentence is:

There is no Wealth but Life.

Through the intelligence exercised by man the infinite stores of energy can be utilized to attain almost any possible development. This is the world to which we are rapidly approaching and it is surely for the scientifically minded to take their share in thinking out the implications of this new order of things, lest imperfect knowledge, spreading down to the proletariat of Marx, should prematurely light the fires of desperation, and the power, which might result in a full and happy life for all, should be short circuited into a useless conflagration.

It is of value therefore to consider how the coming civilization of plenty will deal with economic methods which are accepted in an age of scarcity, how the concepts of a static world must be modified to meet the problems of an essentially kinetic civilization.

It is unfortunate that the scientifically minded are generally so busy with their own affairs that they have no time carefully to consider matters of possibly wider human interest, while those who really do control finance and politics, which directly affect the life of the ordinary citizen, are themselves largely "flat earth philosophers", and have little conception of the real forces at work in the real world.

It may be hoped that the efforts of the British Science Guild and the Parliamentary Science Committee under the guidance of Sir Albert Howard may be the means of bringing some light into this political and financial darkness.

In the remainder of this article an attempt will be made to visualize the implications of the concept of energy as applied to the present social economy.

It will be necessary to consider its effect upon present ideas of *Capital*, of *Interest* and of *Currency* and afterwards, to determine how far mankind is ready to accept such a new point of view. Finally reference will be made to a suggested experimental method

for trying out these new conceptions before the possible advent of a general revolution.

CAPITAL.

Capital is obviously stored energy. The new born child at its mother's breast exercises energy in securing its nutriment, and immediately has added to its wealth, *viz.*, its expectation of life. As time goes on its stored energy increases, until on reaching maturity it represents a serious asset to the community. It has been calculated that the worth of an American boy increases from 9333 dollars at birth to 28,654 at the age of 18. The value of an Indian cooly or even of an Indian student may not be as much as that but it must be considerable. What would be said of anyone who took bullion worth half a lakh of rupees and dropped it in the sea! There might be diving operations to recover it. But apparently little is thought of wasting millions of lives. Human sacrifice to the "Great God Waste" would appear still to be practised.

In the days of slavery owners were not so careless. Slaves at least were as well housed and fed by most of their masters as were horses and cattle. So much was this the case that in a circular sent out to the American banks in 1862 during the Civil War it was stated that "slavery is but the owning of labour and carries with it the care of the labourers, while the European plan.....is that capital shall control labour by controlling wages."

Actually as Henry George pointed out: "It is from the produce of labour, not from the advances of capital that wages come."

It is evident that the labourer brings to his work his accumulated capital, *i.e.*, himself. The moment he drives his pick into the ground he has done $dw \times dt$ of work and the sum of these units, or "quanta" of productive labour increases his capital by the value of such labour. Strictly he does not need *money*. He should require only to present a work certificate to receive the *goods* which he needs, to the equivalent value.

Actually in the Indian countryside labour is largely paid in this way. A well-known Director of Agriculture once stated to the present writer that after twenty-five years experience of Indian agriculture, he could not yet state the cost of ploughing an acre of land. Labour then *is* capital and every man represents so much capital value. This is well understood in Nepal, where, according to report, careful record is kept of every individual born, each of whom is regarded as a potential asset. This brings to mind the famous statement in the "Protocols of the Learned Elders of Zion,"*

"You are aware that the gold standard has been the ruin of the States which adopted it, for it has not been able to satisfy the demands for money, the more so that we have removed gold from circulation as far as possible. With us the standard that must be introduced is the cost of working man power, whether it be reckoned in paper or in wood. We shall make the issue of money in accordance with the normal requirements of each subject adding to the quantity with every birth and subtracting with every death."

Human beings then constitute a large portion of the capital of the State, perhaps indeed the only real capital, since without inhabitants there is no real wealth.

Given human inhabitants capital at once increases, and enormously so with increase of *intelligence*. A Luther Burbank requires a much smaller area of land for comfortable subsistence than a simple ryot. Intelligence therefore is valuable capital, but its exercise depends under present life conditions on adequate food supply. Here comes in the inter-play of sun and labour and life. Again gold, or money based on gold, has little real connection with the matter.

From intelligence arises the *machine* and the application of *power*, and again potential capital is indefinitely increased. Ultimately all this capital comes as we have seen from the sun, and the life force in the growing plant. Gold and speculation would seem to have little to do with the accumulation of real capital. Speculation without industry adds nothing to real wealth, it merely transfers existing wealth from one place to another.

Modern science, then, takes us a step beyond Adam Smith or Henry George, and reveals capital as being ultimately neither labour nor land but *Energy*.

Akin to capital is *credit*. The basis of credit will vary according to our concept of capital. This again varies as has been said, according to the level of perception reached at a given time and place. From a recent conversation with an experienced Scotch banker during a train journey, it would

* In this connection it may be stated that it is of small moment whether the "Protocols" are a real document or a forgery. Men are ultimately moved by ideas rather than by persons. The ideas there expressed are evidently held by certain people in the world and the results are apparent in the recent international situation in regard to gold. By "going off gold" England escaped the threatened disaster.

seem that, as in the case of the Incas and the Spaniards, the perception level has tended to be lower in recent years than in more primitive times. In his early days, this informant related, in the little Scotch bank in which he served, the only securities or valuables committed to the bank's care were such items as old Mr. Macpherson's will or Mrs. Mackay's jewels. Now the safe is filled to bursting with "collateral" in the shape of bonds and shares of various descriptions. In the old days personal *character* was the chief basis of credit, *i.e.*, the belief in the honest activity of the individual.

Similarly in China. The simple "can do" of the Chinese merchant was at one time sufficient security without witness. A new comer, a young branch manager, lost a valuable client, and nearly his own job, through asking for signature and witness from a merchant of the old school who had come to make a deal for "luck" with the new incumbent.

Nowadays a signature and two witnesses are necessary.

Banking as another bank manager once remarked is now little more than pawnbroking—"Gif me ze votch and I gif you ze money."

A constant problem to many is why banks flourish and men decay. As a character in a recent novel by J. B. Priestley exclaims:—"Let's have some marble engineering works and gold-plated shipyards. And we'll have a dole for bankers, and see if we can't give 'em a bit more than they give us."

The coal mines and factories of Stinnes and Kreuger still function usefully, though the millions of their speculative gains have vanished. Stinnes, however, was a true internationalist. He believed that minerals, wherever taken from the earth, should be taxed for the benefit of the world, his idea being to hand over these funds to the League of Nations, or other international body for distribution to those countries requiring development. By such means also a glut of foodstuffs or other commodities in one part of the world and scarcity in another could be rectified. He mentioned, as an example, that a tax of one dollar per ton on all the coal of the world would furnish a fund of £1,000,000,000.

Coal is itself stored solar energy. Other minerals are won by expenditure of labour, dependent as has been said on sun-raised food.

Reference has already been made to the stored solar energy of impounding reservoirs and growing crops.

Capital then is *energy*, credit is *honesty*.

INTEREST.

It is becoming increasingly realised that religion reaches by intuition to facts and principles which are afterwards verified by the intellect. Such intuition indeed is not confined to what is commonly thought of as religious perception. Chemists will recollect the story of the discovery of the law of the linking of atoms, how Kekulé, meditating in a half dream consciousness, saw in his mind's eye the dancing atoms which suddenly seemed to link up, some in chains and some in rings, and how he spent the rest of the night working out the results of this vision. Later, when he was describing the experience in his address at a celebration held in his honour, he said in effect, "Let us learn to dream, but let us verify our dreams by our waking thoughts."

The question of the payment of interest on monetary loans has been the subject of pronouncement by the leaders of religion in the past, as it has again come into the foreground of religious discussion in the present.

The subject frequently recurs in the writings of the Fathers of the early Christian Church. They in fact seem to have deprecated the very idea of private possession, thus Clement of Rome writes, "It is unjust for each to speak of what is his and it is from that that comes division among men."

Ambrose of Milan writes, "Private property is an obstacle in the way of confidence and love."

It is well known that usury is strongly condemned in the *Qur'an*. "The *Qur'an* draws a distinction between trading and usury. In trade the capitalist takes the risk of loss along with the hope of profit, but in lending money on usury the whole of the loss is suffered by the man who uses his labour, whilst the capitalist may count upon his profit even in the case of loss in the actual concern." (*Extract from Commentary.*)

Here may be seen very clearly one reason why industry cannot flourish in India when it is so much easier to lend money in the bazaar at high rates of interest, which interest entails no actual labour on the lender's part, than to sweat blood in building up an industry yielding perhaps 10 per cent.

In a note entitled "The India White Paper and the Co-operative Movement," Sir Daniel Hamilton quotes Adam Smith as follows :—

"In Bengal money is frequently lent to the farmers at forty, fifty or sixty per cent. interest, and the succeeding crop is mortgaged for the payment."

Sir Daniel gives a table of money-lenders' present rates in 25 districts of Bengal. Only in one case are they as low as 10 per cent., in nine cases they are over 100 per cent., in one case reaching 300 per cent.

Put into terms of energy, loaned capital may represent water pumped by the lender into a tank. If he lends that water to a cultivator, he is entitled to the return of what he has lent, or its value at the time he lent it, but the additional value which may arise through the use of the water to drive a turbine or irrigate a crop, is due to the efforts of the borrower or from these efforts *plus* solar energy, and with all this the lender has nothing to do.

It is true that he may hold up the supply of water in order to get more for it, but this is not business but exploitation. It becomes impossible when there is ample rain or river water available, which is what will happen in the new economic system, when all sources of energy are fully utilized.

Under present conditions, moreover, if the borrower strives to pump back water into the tank he finds that the tank continually leaks and his task becomes hopeless for the tank can never be filled. There are apt to be a number of leaks in the tank but the most constant and serious is *interest.*

It is quite obvious that the continual increments of interest which accrue on a sum originally lent by the individual, cannot possibly have any relation to his own efforts.

Quoting again from the "Protocols", speaking of Government Loans :—

"If the loan bears a charge of 5 per cent. then in twenty years the State vainly pays away in interest a sum equal to the loan borrowed, in forty years it is paying a double sum, in sixty treble and all the while the debt remains an unpaid debt."

A striking example of debt increase is given in Walter Jones' "Capital and Labour" (P. S. King & Son).* To emphasise the difference between earning and investing the author states that if Judas Iscariot had started 1,900 years ago, and put aside £10 per week, he would not have been a millionaire to-day :

$$52 \text{ weeks} \times 10 \times 1{,}900 = £988{,}000.$$

If instead of earning, he had invested one penny only at 5 per cent. compound interest, it would during the same period have accumulated to eight sextillions of pounds, approximately :

£8,000000 000000 000000,000000 000000 000000

and, incredible as it may appear, it would require 3,000,000,000 globes of solid gold the size of this earth to pay him in cash.

It is not difficult to see, in the light of such an illustration as this, why the whole of the world under the present system of loans on interest finds itself slave to the banker, and the only outcome must be war or repudiation.

There was wisdom in the idea of the Sabbatical and Jubilee years of the ancient Jews. (Leviticus XXV.)

Walter Jones draws attention to the heavy burdens laid on town and city ratepayers by unrestricted long-term borrowing and urges that the annual redemption of principal should in no case be less than the annual charge for interest.

The present writer finds satisfaction in the recollection that he was able to induce the Finance Department of the Manchester Corporation to set aside large sums *in advance* for the prospective renewal of the sewage filter beds, though a modification of the financial bye-laws was necessitated. By this means interest charges were avoided and the operation had only to be paid for *once.* It may be argued that this was a recurring operation and was not, properly speaking, a capital expenditure. There would seem to be no reason why so-called capital expenditure should not always be paid in advance in this way and thus the perpetual and eternal burden of debt be avoided. The fact that among certain religious bodies a

* Incidentally it may be mentioned that the present writer became acquainted with the late Mr. Walter Jones in the early days of the Activated Sludge process, and it was the engineering ability of Mr. Jones and his staff of the firm of Messrs. Jones & Attwood, which made the process a practical success. The presentation copy of Mr. Jones' book "Capital and Labour" helped to re-awaken in the mind of the present writer old enthusiasms due to youthful studies of Herbert Spencer, Ruskin, Henry George and others.

church or building used for religious purposes, is not allowed to be dedicated until free from debt, shows again that the religious instinct is against the claims of usury. Cases might be mentioned where even building operations were stopped rather than allowed to proceed in the absence of funds actually in hand.

For 100 years the island of Guernsey has issued its own special notes which are legal tender in the community. For projects such as a harbour and marketplace, contractors were paid in these notes, which were afterwards redeemed by the earnings of the projects in question. Here the community borrowed from itself, there was no question of interest, and consequently no permanent debt.

This brings us to the famous case of Wörgl in the Austrian Tyrol where not only was no interest allowed on the money required for public purposes, but if hoarded it *lost* interest month by month.

In Wörgl the "Natural Economic Order" of Silvio Gesell found its application. Gesell pointed out that while gold was practically indestructible the goods purchased by gold suffered deterioration in course of time. Thus "money" value expressed in gold did not keep step with the real value of commodities. Let money depreciate *pari passu* with commodities and there would be no inducement to hoard rather than to spend. Thus would result what is practically "free money".

Wörgl suffered from stagnation and unemployment. The Burgomaster, a disciple of Gesell, decided to transform Austrian money into Gesellian money. Starting with thirty-two thousand schellings of ordinary Austrian money deposited in a savings bank, bonds of 1, 5 and 10 schellings were put in circulation called "Labour Bonds". They lost 1 per cent. of their value every month unless paid into the Municipal Treasury or into the savings bank. This *negative* interest forced the money to circulate freely; hoarding was discouraged but saving was not prevented since the money which returned to the savings bank remained intact. The little town became wonderfully prosperous, taxes were paid in advance, good roads and buildings were provided and everyone was happy and content until the movement spread to other towns and the bankers became alarmed at this encroachment on their prerogative of issuing money, and brought an action against the Municipality. The present state of things in this and other Austrian towns is unknown to the writer. It would seem possible that the savage persecution of the Socialists in Austria prior to the murder of Dollfuss is not unrelated to this successful application of the theories of Silvio Gesell and the consequent panic among the bankers.

The same idea of negative interest enters into the plan of Dr. Townsend in the U.S.A. who proposes that everyone over the age of sixty shall receive a pension of 200 dollars per mensem on the condition that this amount is *spent* every month and not hoarded.

It is stated by the *Christian Science Monitor* that during his examination before the Ways and Means Committee of Congress, "he brought a laugh when he said 'I am not an economist myself, for which millions of Americans have given thanks'. But he went on himself, unsmiling."

The secret of his plan is again the enormous increase of consuming power effected by the more rapid circulation of stored energy; the kinetic as against the static conception of things.

Rent is akin to interest. Anyone who builds a house is entitled to the equivalent of the expenditure of energy employed upon it, *plus* any further work concerned with its maintenance. If the tenant does the repairs the rent will naturally be less. When the tenant has paid the value of the house in rent instalments the house should become his property. In the meanwhile the owner retains the house as security for a loan if he needs it, up to the unpaid value of the house. This is the reverse of borrowing money on an increasingly valuable security such as an insurance surrender value.

Land as Henry George so clearly saw is in a different category from buildings. Land like air and water and sunshine is a common heritage of mankind. It is what he termed a "factor of production". To hold land in expectation of its increasing value through the expenditure of energy by others is plainly exploitation. The extent to which the public has been robbed in this way in the early days of railways and of growing cities make the exploits of Robin Hood and highwaymen of later date seem like nursery games. Gangsterdom is no new phenomenon in the United States. The land speculator takes toll of every drop of water in the reservoir of wealth, through owning the land on which, as it were, the outlet sluices are placed.

It is these things which caused Mussolini to exclaim: "I am for those who seek to make technique perfect in order to dominate elements and give to men more sure footing for the future. I do not respect I even hate those men that leech a tenth of the riches produced by others."

Some excuse may be admitted for the rather violent tone of the last sentence, since he is there concerned with the real enemies of his country. It is a pity that on the other hand he should by his militaristic propaganda influence little children to regard as enemies those who, in a better world, would only wish to be their friends.

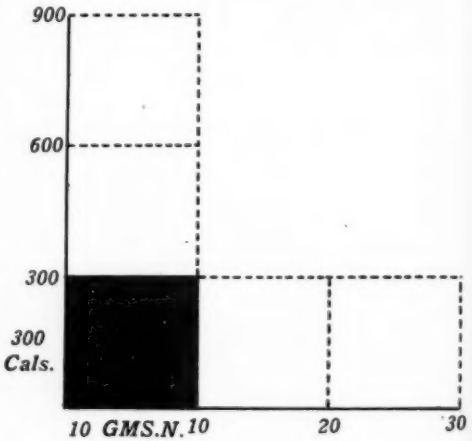
Among the 25 points of the National Socialist German Workers Party are the following as given in Hitler's autobiography, "Abolition of income unearned by work. No speculation in land. Death penalty for usurers and profiteers."

From the Williamsburg Bridge in Greater New York can be seen the whole skyline of Manhattan. Every day it is different they say, as new buildings rise and the old are pulled down. Gazing on this scene of pulsating life, the "Fire Magic" of "Die Valkyrie" echoes in memory. The land-speculator is no Siegfried that he should control these leaping flames of energy.

CURRENCY.

The subject of currency as viewed under the Energy concept has already been dealt with tentatively in an article by the present writer entitled "Chemistry and Currency" published in *Current Science*, Vol. I, No. 2, 1932. An accountancy unit was suggested called the ERN, being the daily *Nitrogen* ration of an adult human being together with its equivalent energy. This nitrogen ration, consumed as protein in various forms, such as meat, fish, milk, curd, peas or beans, may be taken without serious error as 10 grams and the corresponding energy liberated as it passes through the human system as 300 calories. This suggestion was first published in *Capital* on March 3rd, 1932, quite without knowledge of similar trends of thought in the writings of Professor Soddy of Oxford, of H. G. Wells and of Sir Daniel Hamilton, whom the writer had the pleasure of meeting shortly afterwards. An attempt to bring the idea before the Rotary Club of Calcutta met with little response, in fact with some amount of ridicule. Nevertheless it was subsequently learned as already mentioned, that the basic idea had been in operation for 25 years at the Victoria Falls and Transvaal Power Company, and that the Technocrats in the United States proposed to base their accountancy unit on the kilowatt hour. Actually every engineering concern works out its costs largely on Man-hour consumption.

Subsequently, in the discussion in the *Charka*, the organ of Calcutta Rotary, the following diagram of the ERN was published and it may serve to make clear the basic idea of this unit of currency.



The ERN is really a unit of *Wealth* since it represents the two fundamental *factors of production* to use the term employed by Henry George. He considered land, labour and capital as the three factors of production, but later spoke of them as two, *viz.*, natural substances and human exertion—which two factors by their union produce all wealth. We have seen that the more modern conception of the two factors of production would be food (or Nitrogen the most constant element in food) and energy. Thus according to the foregoing diagram, the calories, or equivalent energy units, produced by a high-powered machine, operated by one man, would extend vertically to an indefinite height. No one could argue that the one man himself *produced* all that energy or that he could lay claim to its resultant "goods" on that account. Still less, however, could there be a claim to such energy simply on account of certain payment in *money* by individuals who have no other claim to its possession. The origin of the machine indeed lies deep in the past of the race and is the outcome of the work and inventive

thought of countless minds. There can be no inherent possessive right to the machine any more than to the enhanced ground rents in Manhattan created out of the labour and thought of the myriad sojourners on that island.

On the other hand if the Nitrogen side of the ERN diagram is extended we have a representation of the value of the crop sown or cultivated by one man but grown with the assistance of sun and air.

Further we have the vast reservoir of Nitrogen, contained in human, animal and vegetable nitrogenous waste material, or recoverable from the atmosphere by the activities of the nitrogen fixing bacteria.

In an article entitled "Scavengers All" in the *Harijan* for March 15th, 1935, Mahatma Gandhi quotes with approval the data collected by the present writer, according to which the human excreta at present worse than wasted in India, represent if wisely used an annual gain of 60 crores of rupees to the country.

We find indeed that all real wealth is in fact the natural inheritance of all who will work in co-operation with the forces of nature and their fellowmen to produce it. Money is *not* wealth, it is only a claim to wealth through the performance of labour.

It may here again be emphasised that payment in ERNS does not mean equal payment for all, nor that the *value* of any piece of work depends on the physical energy expended in its execution.

The ERN is a measure of *wealth* in the sense that an inch is a measure of *length* or a pint a measure of *capacity*.

Payment in ERNS means, however, that the reward of labour whatever it may be, is not dependent on the scarcity of a metal, or the whim of a banker.

As stated earlier the idea of an energy unit as a basis of accountancy is not new and will almost certainly in some form be adopted in the new world to which many are looking forward. The advantage of the ERN lies in the combination of the two factors, food and energy, so that it can serve as a measure both of the mechanical and agricultural wealth of a country. Thus in the Cauvery Falls the Mysore Government has an unfailing source of energy units, every 300 calories of which is equal to one ERN: in its fields is produced so much protein Nitrogen, every 10 grams of which is equal to one ERN.

It cannot be sufficiently emphasized that the coming of the telegraph, the aeroplane and the radio, and now on the horizon, television, has caused the world to close up its boundaries to an indefinite extent; it is easier to communicate between Bombay and London than it was between London and Edinburgh less than a hundred years ago. All the vast tangle of national currencies as well as weights and measures must inevitably disappear with the growth of intelligence. Even before this ancient clutter is discarded some form of international currency will become imperative. The writer was impressed, *e.g.*, with the fact that in travelling from Madras to Shanghai without at any point leaving British territory, it was necessary to change his money about half a dozen times. A certain type of individual in Shanghai manages to maintain existence by buying and selling currency according to the reports of the tape machines.

In this connection the effect of climate on industrial development should not be forgotten. It is very strikingly shown on a map given on page 125 of Lord Melchett's *Modern Money*. A quaint philosopher's one reply to all suggestions for reform in India was: "You must alter the path of the Sun." No one would deny that much can be done to modify the effects of climate, but as a general proposition, climatic differences are likely to control the economic situation for a considerable time to come and therefore an international currency which is equally useful both in an industrially developed country and among a more agricultural population, has manifest advantages.

A word may be said here with regard to an objection which has occasionally been voiced, namely, that with the issue of ERN notes it would be difficult to avoid inflation. On the contrary, the issue of notes of this kind would probably be always far behind their potential backing in real wealth, since though it is not easy to make a complete assessment of a country's potential wealth, it can be arranged without difficulty that the ERN issue shall not exceed a certain proportion of the ascertainable assessment.

The mere indiscriminate printing of so-called money as was done in Germany is now realised to have been an act of lunacy which is not likely to be repeated.

POSSIBILITIES OF CHANGE.

It is now to consider how far the state of consciousness of the world is ready to accept the ideas set out in the foregoing thesis and in the many similar writings on which it is based.

The main hindrance to acceptance of such views is the need, which becomes apparent at once on a study of the situation, for the elimination of the *Profit Motive* in industry. No less an authority than Sir Josiah Stamp states that the "mainspring of all individual enterprises is the getting of profits." There are very serious grounds for disagreeing with him. To begin with the whole of Soviet Russia carries on without the profit motive as commonly understood: emulation, yes; increased remuneration for good work done, yes, but that is nothing more than occurs in every reputable Civil Service whose members would be indignant if accused of working simply for money.

The whole training of youth in Russia is against the very idea of profit making. A young Russian lad was asked, 'If a man buys 6 dozen apples at 18 kopeks a dozen and sells them at 36 kopeks a dozen what does he get?' The boy's answer was "A jail sentence."

The rise of the Rotary Club movement with its motto "Service before Self" is certainly significant. Many of the greatest business or even capitalist leaders such as Henry Ford can rightly accept this motto since their object is not *personal* possession but service to the community.

Rumour stated that the personal expenses of Cecil Rhodes did not exceed £600 a year.

It is the evil lust of *personal possession* that is the enemy which has to be fought. M. P. Willcocks writes:—

> "The passion to possess, though it is judged now by many to be the very tap-root of misery and wrong, has only recently come into the zone of conscious thought because its worldwide sway as a motive has only recently been recognized."

Soames Forsyte in fiction and Pierpont Morgan in real life are typical examples of the "possessive" complex. Both had a fine taste in art and also for the market value of the objects of their desire. With Soames Forsyte his claim to possession extended to the person of his wife. Pierpont Morgan is reported to have said, "I can buy any 'scientific' man for 500 dollars and make half a million out of what he tells me." Already, however, the number of Soames Forsytes in the world is rapidly decreasing, and the reputation of Wall Street has recently been sadly blown upon.

To use the word employed by Professor Miles Walker, a *eudæmonistic* spirit is now widely manifested. Professor Miles Walker states that this eudæmonistic quality is very often found in engineers and scientists:—

> "A man has this quality when he throws the whole of his energies into the carrying out of sound, practical and beneficent projects for the sake of those projects themselves and not primarily from selfish motives or in pursuance of some irrational prejudice."

The chief desire of such men is to *live* and not to be continuously pre-occupied with the means of living. With more and more of these men in the world, the selfish quarrels of politicians and fomentors of racial antipathies, with all such wastes of human energy, will disappear like the clamour of a bad dream which has overpassed. In the meanwhile what practical steps can properly be taken?

STEPS TOWARDS RECONSTRUCTION.

In the first place without doubt a determined effort must be made to lift the burden of *interest*, the grasp of the dead hand, from the coming generations.

That such a step is possible, even in a conservative eastern country, is shown by the case of Siam where the philosophy of the gentle Gautama forbade violence but also insisted upon justice. In consequence the Government stepped in and passed a law enabling the farmers of every village community to form themselves into a Co-operative Society that would adopt and become collectively responsible for the debts of each individual member. Any society, once formed, could approach a bank (guaranteed by the King) for a loan sufficient to pay off all the money-lenders operating in that district. The Society has to pay 6 per cent. interest for this accommodation to the bank; and it is allowed to charge 12 per cent. to its members. It may thus amass in course of time a balance for the liquidation of its indebtedness to the bank and to provide capital for the acquisition of modern agricultural implements. It is calculated that after a period of not more than 25 years the rice cultivators of Siam will not owe a tical to the foreign usurers and then it will be possible without offending Buddha to banish every money-lender from the country.

The reduction of interest on British or British Indian Government Loans is already rapidly taking place as can be verified in the experience of the majority of people. That this presses hardly on the "rentier" cannot be denied, but in time such a class will diminish, possibly even in France. It must

be remembered that with reduction of interest there must go also a reduction in Income-Tax so that the net effect is not so serious as it might appear.

In the coming time moreover there will exist far fewer "old" people who are merely spending their time. Increase of *life* will mean increase of wealth sufficient to support such people in a happy bright existence very different from what is now often their lot.

It should no longer be possible to plead lack of money for not proceeding with "nation building" activities; where men and materials exist, there is also wealth.

Already Sir Montague Webb has put aside for the time his strenuous advocacy of an increase in silver currency and at a public meeting in Karachi, presided over by the Mayor, proposes the issue of "Service Notes" which would circulate like ordinary currency, to raise funds for a water supply scheme for Karachi estimated to cost Rs. 1,50,00,000. Sir Montague quoted the case of the Guernsey market mentioned earlier in the present paper. He very properly stresses the point that his scheme would have to be pushed with great persistence and determination as it would be opposed from all sides, more particularly by the money-lending classes.

There have been many suggestions for experimental colonies to try out some of the ideas adumbrated in the foregoing pages.

In Burnaby, British Columbia, the "Army of the Common Good" has set about organizing a life where production shall be for use and money shall be a system only of Labour Notes sufficient to exchange mutual services.

Captain Petavel in India has for long advocated Educational Colonies where youth should earn while learning.

Lt.-Col. H. Jarrett-Kerr as Representative of the Rural Reconstruction League of India writes of a Co-operative Commonwealth where there would be no hoarding or cornering the medium of exchange and where there would be equal distribution of commodities and services.

Professor Miles Walker writes to a member of the staff of the Indian Institute of Science urging an experiment to be carried out by volunteers, the main thing differentiating the experimenters from the rest of the people being their type of money designed to bring about a free circulation of all commodities manufactured by the community. "This community would trade as a whole with the outside world, just as India now trades with a foreign country for things they cannot produce themselves."

Some months ago a sketch of such a project was submitted to the present writer according to which a number of young educated Indians were to start some kind of Industrial Colony on their own, which would begin by borrowing capital at 5 per cent. interest. It was pointed out that such a suggestion must necessarily wreck the scheme at the outset, since there were very few industries which could pay a steady 5 per cent. in addition to necessary expenses of labour and material, when averaged over the period of inception and full running, and that the only result would be that the young pioneers would begin their existence as slaves to the money-lender. It was pointed out that they *themselves* were Capital with their combined ability and education. It was impressed upon them further that all living things grow from seed and that without this element of life amongst them, nothing could ultimately develop, with it all things were possible. The case of Henry Ford himself who started as a motor mechanic was quoted, and the history cited of his famous encounter with the bankers who in time of crisis came as friendly spiders offering the shelter of their "parlour" to him, the innocent fly.

The only sound method for beginning an industrial colony of this sort must be for the members each to contribute what little they have, like the citizens of Wörgl, and then to circulate that deposit in the form of "Work Tokens" for the energy which would find its first outlet, may be, in tilling the ground or building a shack, out of which one day would emerge the industrial village, or even the industrial city. Their real capital would be their knowledge, their physical energy and their character.

Sir Daniel Hamilton has successfully launched a Co-operative Colony on his Gosaba estate in the Sunderbans, Bengal.

His scheme includes the following proposals:—

1. That the Government of India lends say Rs. 1,50,000 for the establishment of a Bolpur-Gosaba Training Institute for co-operative workers.

2. That the Government of Bengal place at his disposal a block of land in the Sunderbans for the purpose of creating an estate of say 10,000 acres, to be worked on co-operative lines, which estate will remain the property of the Government of Bengal.

3. That the Government of India lends the money required for the development of the estate, say about Rs. 2,00,000.

He states that the question of financial stringency does not arise as the finance required for the schemes thus outlined does not cost either the Government of India or the Government of Bengal anything, the credit required is found not by borrowing or by taxation, but by monetizing the brain-power of the Bhadralok and the hand power of the people.

Sir Daniel bases his policy on the practice which obtained in the old days in Scotland when banks issued their own notes and used them to finance young men of known antecedents and good character. It was in this way that the foundation was laid of the agricultural prosperity of Scotland.

It may be remarked that all these schemes have some analogy with the Co-operative Wholesale Society whose operations are now on a very large scale. It may be doubted, however, whether the questions of money and interest have been fully thought out by the members of this Society. In the community envisaged by those who are controlled by the concept of Energy, every worker at the end of his daily task will simply require to have his worksheet signed by some responsible individual when he would go to an office either of the special community, or, later on, to the State, when the idea becomes universalized, and obtain the proper equivalent in ERNS to be exchanged for goods in payment for his completed task. It may be anticipated that these ERNS, if unspent, will only maintain their value like the Wörgl "Work Bonds" for a definite period, after which they will lose interest steadily, unless put into the State or Community Savings Bank, where they will not earn interest but will remain available for spending at some other time.

Professor Miles Walker rightly states that the method of the scientific man or the engineer is to make trial by experiment of the new ideas which have come to him in the course of his thinking. The trouble about many of these experiments in the past has been that the governing conditions of success have not been fully understood or sufficiently explored. With all the resources of modern science and the freedom of modern thought these hindrances to success should be recognized and dealt with at the outset. Freedom of thought is perhaps the most essential need before any useful social experimentation can be put in hand. It is strange how few are really free. The man of science, knowing that twice 2 remains 4, not only sometimes but all the time, should be unaffected by the taunt of adherence to any "ism", political or economic. He is merely concerned with the truth of things, which, in the end, must make men free. In the atmosphere of true scientific thought there can be no room for prejudices or selfish fears, nor, it may be added, for selfish ambitions.

It is important to remember that in the modern world changes of thought come about with accelerated velocity.

Throughout the whole period of recorded history, prior to about a hundred years ago, the speed of locomotion did not exceed the speed of a horse. Then came the locomotive.

It is a mere thirty years since the first aeroplane made its "faltering flight" over the Dayton sands.

These changes manifestly express a corresponding liberation of thought in regard to the problem of locomotion.

Is there not hope therefore that similar progress may be manifested in the attitude of mind with which humanity faces the problems of war and poverty?

The perils of "mass-suggestion", and the many means for producing it, are becoming widely recognized as a cause for grave concern.

Why should not the same or greater energy be employed to disseminate right and true ideas? Let us hope that the projected development of Broadcasting in India will be used to spread wisdom as well as knowledge.

The deep importance to the present world of a fundamental change in viewpoint is sufficiently evident, and the foregoing exposition may fittingly conclude by quoting the last paragraph of Silvio Gesell's Treatise on "The Natural Economic Order."

"Everyone would of course like to enjoy the blessings of civil and international peace, and at the same time live on capital-interest. But those who have discovered that the possibility of doing so is a Utopian fantasy, an illusion of naive minds: those who recognize that war and interest are inseparable, must choose one or other of these alternatives: either interest and war, or earned income and peace. Such persons, if really animated by peaceful Christian feelings, will accept with rejoicing the latter alternative; such persons have the right inner preparation for understanding "The Natural Economic Order"; it is for them that the book has been written, and it is they also who, undeterred by opposition, will carry through the reforms it proposes."

SUMMARY.

The vast possibilities of the utilization through modern scientific discovery of the unlimited resources of solar energy are illustrated by examples. Attention is drawn to the fact that energy units have already been used in practice as a *Measure* of value.

The terms *value* and *profit* are distinguished and reference is made to the difference of viewpoint exemplified by the civilization of the Incas and that of their Spanish conquerors.

An analogy is suggested between the conception of heat as *caloric* and of gold as *wealth*. In the modern world the concept of *energy* should control true economic thought, rather than any one material substance such as gold.

It is shown that in the world of plenty foreshadowed by the achievements of physical science, production for *profit* is ultimately impossible, except by exploitation or war.

Attention is called to the importance of thinkers trained in the methods of modern science devoting consideration to the problems of present day economics, if disaster is to be avoided.

The consequences of the concept of energy are considered in relation to *Capital*, *Interest*, *Rent*, *Land* and *Currency*.

The suggested unit of *Man-Power*, known as the ERN (*viz.*, the daily Nitrogen ration of a man, with its corresponding energy value), is explained, and its advantages as a universal currency medium discussed.

The question as to how far the thought of the modern world is ready for the new kinetic viewpoint is considered and several encouraging signs are noted.

Finally reference is made to recent efforts, embodying some of the ideas set out in the article, and the need is again urged for the co-operation of thoughtful people in the building of a new world.

References.

The following sources of information were consulted in the preparation of the foregoing paper:—

BOOKS.

Adams, W., *Real Wealth and Financial Poverty.*
Angell, Norman, *The Peace Treaty and the Economic Chaos of Europe; The Money Game; The Unseen Assassins.*
Arkwright, Frank, *The A.B.C. of Technocracy.*
Bagehot, Walter, *Physics and Politics.*
Baldwin, Oliver, *Unborn Son.*
Bellamy, E., *Looking Backwards.*
Blackett, Sir Basil, *Planned Money.*
Brayne, F. L., *Socrates in an Indian Village; Village Uplift in India.*
Brown, William, *The Inherent Function of Money.*
Cole, G. H. D., *The Intelligent Man's Guide through World Chaos.*
Crookes, Sir William, *The Wheat Problem.*
Darling, J. E., C.B.E., *The "Rex"—A New Money to Unify the Empire.*
Douglas, C. H., *Social Credit.*
Field, A. N., *The Truth about the Slump.*
Forbes, Rosita, *Eight Republics in Search of a Future.*
Ford, Henry, *My Life and Work.*
Fowler, Gilbert, J., *Introduction to the Biochemistry of Nitrogen Conservation.*
George, Henry, *Progress and Poverty.*
George, Lloyd, *The Truth about Reparations and War Debts.*
Gesell, Silvio, *The Natural Economic Order.*
Gibbs, Sir Philip, *European Journey.*
Hawtrey, R. G., *The Gold Standard, Theory and Practice.*
Henderson, Fred, *The Economic Consequences of Power Production; Foundation of the World's New Age of Plenty.*
Hitler, A., *My Struggle* ("*Mein Kampf*").
Hodgson, John, *The Great God Waste.*
Hurst, *Mechanism of Creative Evolution.*
Huxley, Julian, *A Scientist among the Soviets; Scientific Research and Social Needs.*
Jameson, Storm, *No Time like the Present; The Decline of Merrie England.*
Jones, Walter, *Capital and Labour.*
Lawrence, Pethick, *The Money Muddle and the Way Out.*
Martin, Kingsley, *Low's Russian Sketchbook.*
Marx, Karl, *Capital.*
Maxwell, D. W., *The Principal Cause of Unemployment.*
Melchett, Lord, *Modern Money.*
Meulen, Henry, *Industrial Justice through Banking Reform.*
Mussolini, Benito, *Biography.*
Newsholme and Kingsbury, *Red Medicine.*
Nichols, Beverley, *Cry Havoc.*
Pratt, Ambrose, *Magical Malaya.*
Priestley, J. B., *English Journey; Wonder Hero.*
Prescott, *Conquest of Peru.*
Robertson, D. H., *Banking Policy and the Price Level.*
Roosevelt, F. D., *Looking Forward.*
Ruskin, *Unto This Last.*
Salter, Sir Arthur, *Recovery.*
Scott, Howard, *Introduction to Technocracy.*
Shaw, G. Bernard, *The Political Madhouse in America and nearer Home.*
Simonds, Frank H., *America Must Cancel.*
Smith, Adam, *Wealth of Nations.*
Soddy, Professor, *Money versus Man; Wealth, Virtual Wealth and Debt.*
Thwaites, Lt.-Col. Norman, *Velvet and Vinegar.*
Wells, H. G., *The Work, Wealth and Happiness of Mankind; The Shape of Things to Come.*
Willcocks, M. P., *Between the Old World and the New.*
Wingfield Stratford, Esmé, *The Victorian Aftermath.*

ADDRESSES, SPECIAL ARTICLES, PAMPHLETS, AND REPORTS.

Eddington, Sir Arthur, *Lecture Recorder*, December, 1932.
Ewing, Sir Alfred, "Power", Address to the Engineering Section, British Association.

Fowler, Gilbert J., "The 'Ern', a New Medium of Exchange," *Capital*, 3rd March, 1932; "Chemistry and Currency," *Current Science*, Vol. I., No. 2, August, 1932.
Hamilton, Sir Daniel, *The Man Standard; The Co-operative State and How to Reach It; The New Constitution and the Bread Problem; Rural Reconstruction; The India White Paper and the Co-operative Government.*
Hodgson, John L., "Some Aspects of the Problem of Industrial and Communal Waste, with Discussion," *Journal of the Royal Society of Arts*, February 19th, 1932.
Hopkins, Sir Frederick Gowland, "Some Chemical Aspects of Life," Presidential Address to the British Association, 1933.
Jarrett-Kerr, Lt.-Col. H., "Year of Jubile" Rural Reconstruction League of India.
Jarvis, J. Gibson, "Instalment Buying," *Journal of the Society of Arts*, April, 1932.
Jones, Gavin, R.T.C., "Note on the Economic Situation for the consideration of the Upper India Chamber of Commerce."
Keeble, Sir Frederick, "The Green Plant as Agricultural Engineer," Hawkesley Lecture, Institution of Mechanical Engineers.
Kitson, Arthur, "Letter to H.R.H. the Prince of Wales on 'The World Crisis, Its Cause and Remedy.'"
Leverhulme, Viscount, Presidential Address to the London Chamber of Commerce.
Petavel, Captain, Numerous pamphlets on Educational Colonies.
Walker, Professor Miles, "A Call to the Engineer and the Scientist," Presidential Address to the Engineering Section, British Association, 1932.
The Rural Report of the Liberal Land Committee, 1923–25.
The Protocols of the Learned Elders of Zion.
Publications by the Industrial Christian Fellowship.
Interim Report to the Church Assembly of the Social and Industrial Commission on Unemployment.
"Monetary Reconstruction," Monetary Reform Association.
Times Supplement on Gold, June 20th, 1933.
"The Case against Gold," *The Times*, April 9th, 1934.

GENERAL.

The subject has been followed in the newspaper and magazine press: particularly in the *Christian Science Monitor*, the *Statesman*, the *Chamber of Commerce Journal* and the *Lecture Recorder*.

Numerous articles by competent writers occur in such popular publications as *Nash's Magazine*, and *Passing Show*, indicating the wide appeal of the subject.

In the *Planters' Journal*, 1932–33, a correspondence between Sir Montague Webb and the present writer was followed by a valuable series of articles by Major B. J. Temple.

Mention may be made of the weekly paper, *Life*, published in Bangalore and edited by E. Kirk, which has devoted its first attention to the discussion of modern problems in Economics.

Trade and Industry.

SINCE the above was written, we have come across an account of the proceedings of the fiftieth anniversary of the School of Incorporated Accountants and Auditors, London (*The Chamber of Commerce Journal*, May 1935, page 360). In the course of his reply to the toast by "Trade and Industry" proposed by Sir Josiah Stamp, Sir Stephen Demetriadi, President of the London Chamber of Commerce, quoted the old rhyme:—

"The centipede was happy quite,
Until the toad in fun
Asked him which leg went after which
Which worked his mind to such a pitch
He lay distracted in a ditch
Considering how to run."

and said, "We had succeeded in making what was comparatively simple business, so complex that trade and industry, like the centipede, were lying down and passing quietly away. In simpler and saner days, it was clearly understood that the reason why a man produced was that he, his friends, relatives and retainers might consume, and these simple souls would have been amazed to learn from us that what they should have done to become truly wealthy was to have restricted the production, burned or otherwise destroyed some of it, and in this way, by making it scarcer, made it more valuable..... It sometimes seemed that the present impasse was so essentially devoid of reason that perhaps the answer hidden for the wise and prudent, might yet be revealed to babes and sucklings. The centipede might forget all about the toad and just get up and walk quietly away."

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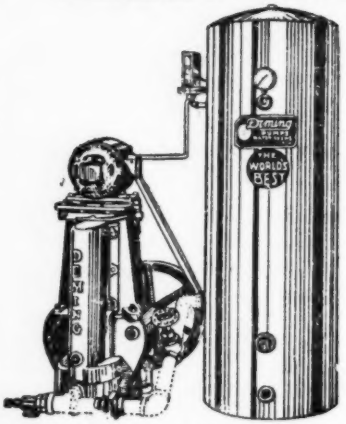

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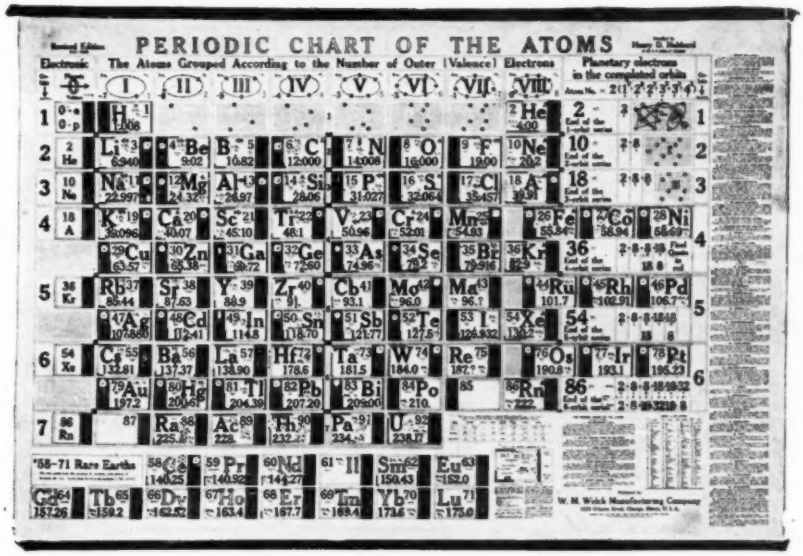
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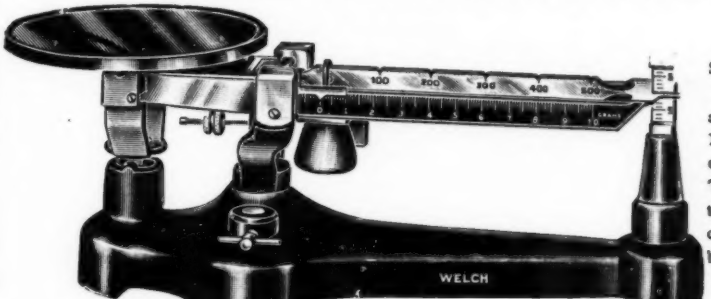

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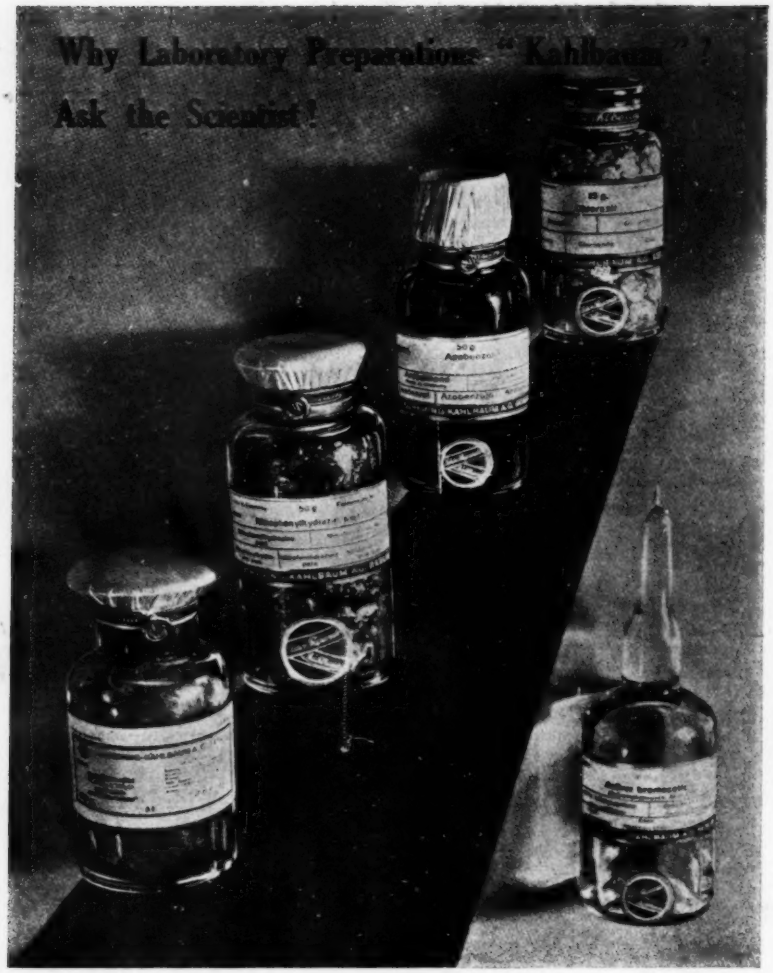

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